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JOURNAL OF ELECTRICITY

POWER AND GAS

Devoted to the Conversion, Transmission and Distribution of Energy

Entered as second-class matter May 7, 1906, at the Post Office at San Francisco, Cal., under the Act of Congress March 3, 1879

VOL. XXIII NO. 26 | SAN FRANCISCO, DECEMBER 25, 1909 | PER COPY, 10 CENTS

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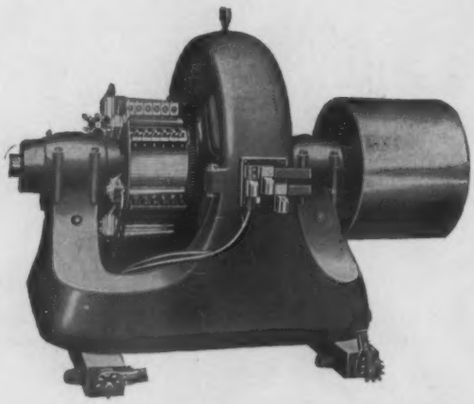

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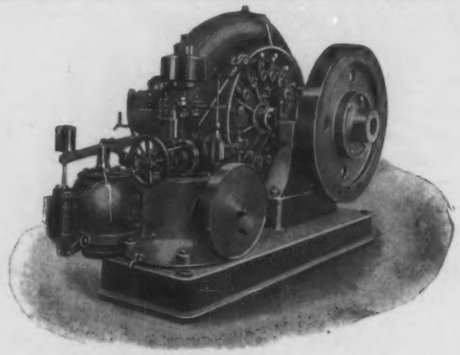

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JOURNAL OF ELECTRICITY
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VOLUME XXIII. SAN FRANCISCO, DECEMBER 25, 1909. NUMBER 26.

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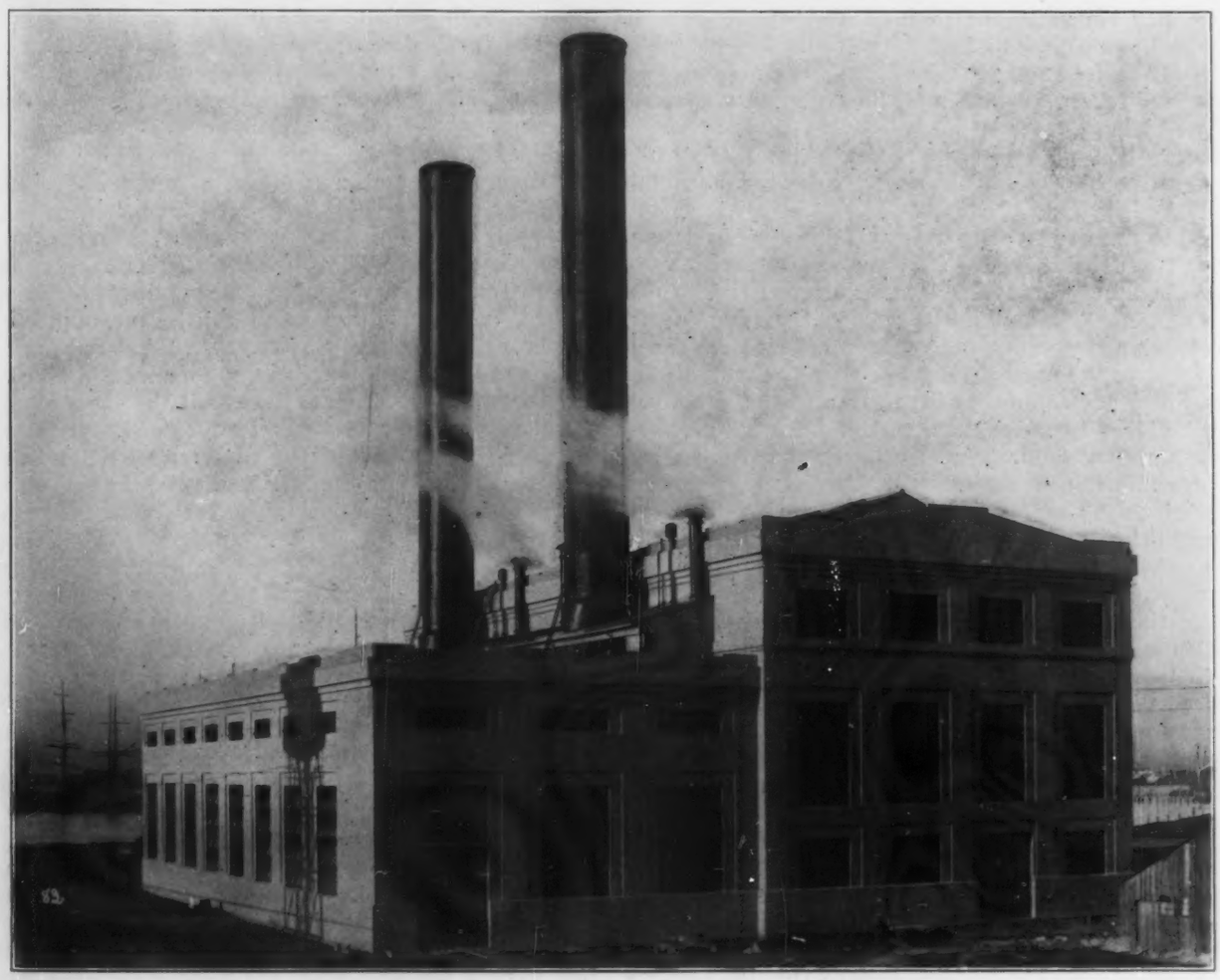
AUXILLIARY STEAM PLANT FOR THE GREAT WESTERN POWER COMPANY

The steam plant of the California Electric Generating Company, generally known as the Oakland Power Station, located at Sessions Basin, East Oakland, serves as an auxiliary to the Great Western Power Company's 40,000 k. w. hydroelectric plant on the Feather River at Big Bend, eighteen miles above Oroville, California. The electric energy generated in this station can be delivered into any part of the transmission system of the power company through the Oakland terminal station of the company's 100,000 volt transmission line from the water power plant at Big Bend. The Oakland Power Station thus forms a valuable and important part of the Great Western Power Company's system and insures continuous and uninterrupted service, as power from this auxiliary plant can be supplied immediately to any part of the



The Oakland Power Station of the Great Western Power Company.

company's distributing system in case of trouble at the hydroelectric plant, or with the 100,000 volt transmission line.

The Oakland Power Station, although installed primarily as a reserve plant, represents the highest type of modern power station equipment and construction, and no effort has been spared to secure a plant that will effectively meet the severe requirements of operation imposed upon a station of this kind.

The station contains three 3500 k. w. units with space for a fourth, and is designed for a later extension to accommodate four additional units, giving the station an ultimate capacity of eight units.

The units are arranged for independent operation, each turbine being supplied by a battery of water tube boilers, and exhausting to a surface condenser; the condenser in each instance being equipped with a full set of auxiliaries. The piping system is interconnected in such a way that the steam supply to the turbines may be drawn from any desired combination of boilers. In so far as the arrangement of the auxiliary machinery is concerned the units may be said to be arranged in pairs, thus minimizing the operating attendance and adding to the flexibility of the station. The discharge from the wet vacuum pumps of two condensers is pumped to a combined feed water heater and hot well. The boiler feed pumps take their suction from this heater, discharging into a duplicate system of feed water piping.

The boiler plant is arranged for burning fuel oil, a very complete oil piping system having been installed.

The fresh water for make up purposes is drawn from two deep wells on the company's property, a reserve supply being available from a connection to the city water. The water for condensing purposes is taken from the estuary and discharged into the canal adjacent to the company's property.

Special attention has been given to the design of the building in order that it shall meet all requirements, both structural and architectural, as well as to secure an arrangement specially adapted for operating conditions. The foundation consists of a concrete monolith, 6 ft. thick for the main part of the building and increased to 15 ft. under the stacks and to 110 ft. 6 in. for that portion forming the tunnels for the circulating water for the condensers. The entire foundation is heavily reinforced with steel rods and is supported on piles driven to resistance in the clay and spaced 3 ft. on centers over the entire area. The superstructure is of steel frame construction with reinforced concrete walls, floors and roof and with metal doors and windows, the structure being fireproof throughout. The building consists of two main divisions, the boiler room having a floor area of 60 ft. x 155 ft. and the turbine room having a floor area of 75 ft. x 157 ft. It is provided with unusually large window area, which together with the skylights and monitors in either division give an abundance of light and ventilation. The building is designed along severe lines securing a substantial and dignified effect; the treatment of the exterior is of a style specially adapted to the character of the building and to the materials of construction.

Two self-supporting steel stacks are installed, each being 10 ft. 6. in. outside diameter, and 150 ft. high above the boiler room floor. The stacks are constructed of steel shells lined with a 6 in. fire brick wall to height 6 ft. above the entrance of smoke flues, and with 4 in. reinforced concrete wall from this level to the top of the stacks.

The turbine room of the station is equipped with a 30-ton Niles electric operated traveling crane with 5-ton auxiliary hoist, and operated by four alternating current variable speed induction type motors.

The equipment for station service is complete in every detail; a 110 k. w. 11,000/440 volt, three-phase, oil-cooled transformer connected to the power buses supplies power for the operation of the crane, air compressor and sump pump motors and also for the motor driven exciter. The building is lighted by current from a 25 k. w. 11,000/110 volt single phase transformer. A direct current reserve lighting system is also installed, being connected to the exciter buses. The station is also equipped with a storage battery supplied from the exciter buses, thus assuring continuous power for the operation of the oil switches and for the station lighting. A complete air system is installed for cleaning purposes with outlets for hose connections at various points throughout the building.

The turbo-alternators are of the new horizontal Curtis type, manufactured by the General Electric Company, and are designed for a normal continuous capacity of 3500 kilowatts. The turbine is a five stage machine, designed for operating with steam at 205 pounds pressure and a superheat of 100 deg. F. The generator operates at 1200 r. p. m., and delivers current at 11,000 volts 3 phase 60 cycles, the armature being star connected, but the neutral connection is not brought out. Ventilation of the windings is accomplished by means of a small Sturtevant multivane blower, with a capacity of 13,500 cu. ft. per minute. This fan is attached directly to the main turbine shaft and discharges through a duct into the base of the machine. The air currents lead through armature openings in the end of the field, and circulate out through the ducts in the laminations of the armature, discharging out of an opening in the top of the housing.

The lubrication of the turbine bearings and the supply of oil to the hydraulic governor gear is furnished by a rotary geared oil pump driven from the main turbine shaft. As an auxiliary supply the turbine is equipped with a duplex steam driven pump, which may be used in starting the turbine, or in case of failure of the ordinary supply. The oil system is furnished with a spring relief valve to maintain a constant pressure of supply. All of the turbine bearings are water jacketed, the water supply being taken from the service lines in the station. The overflow from the bearing jackets is visible so that this supply of water may be properly regulated. The speed of the turbine may be regulated within certain limits by means of a motor control connected with the governor, so that the switchboard operator may control the speed of the machine when synchronizing and when adjusting the load.

From the standpoint of mechanical design, the turbo-generators are of rugged construction to withstand the severe requirements of emergency service.

The turbine and generator are mounted on a heavy cast sub-base to move against deflection or vibration under load. The main shaft is made in two parts, with a flanged coupling adjacent to the center bearing. Endwise adjustment of the shaft is maintained by a roller thrust bearing located next to the main bearing on the steam end of turbine. The amount of steam supplied to the carbon packing rings on the shaft is regulated automatically by a device connected to the governor gearing. The principal dimensions of the turbo-generator are as follows: length over all, 30 ft., width, 14 ft., height, 12 ft.; the total net weight is 250,000 lbs. Special interest attaches to these units from the fact that they are the largest horizontal machines of the Curtis type that have been installed up to the present time.

Engine Room of the Oakland Power Station.

Three exciter units are installed in the station, each of a capacity of 75 k. w. Two of the exciters are turbine driven and are connected to Curtis turbines operating at a speed of 2400 r. p. m. The motor driven exciter is connected to a 100 h. p. 3 phase 440 volt induction motor, running 1200 r. p. m.

The condensing equipment was furnished by the Alberger Condenser Company, and consists of the following apparatus for each unit: one surface condenser containing 8,000 square feet of surface of 1 in. No. 18 B. W. G. tubing; one circulating pump with a capacity of 6,800 gallons per minute; one 10 in. x 22 in. x 18 in. rotative single stage dry vacuum pump; one 3 in. centrifugal single stage wet vacuum pump direct connected to an 8 h. p. Kerr steam turbine; and a duplex pump 6 in. x 5¾ in. x 6 in. for keeping the condenser and circulating pump primed. The condenser is connected to the turbine through a corrugated copper joint, to take up the expansion and contraction. In the construction of the condenser, the tubing is expanded into the tube head at one end, and is secured through a ferrule and packing at the other end. There is no hot well connected directly to the condenser,, the function of the hot well being served by a reservoir in the upper part of the feed water heater.

The feed water heaters contain 1600 sq. ft. of heating surface each, of ¾ in. No. 18 B. W. G. brass tubing. As before mentioned, one heater serves to receive the water from two condensers. The feed water is heated by the combined exhaust from the auxiliaries, all being operated non-condensing. As an additional source of steam for heating the feed water, a steam line is provided leading from the second stage of the turbine to the heater.

The boiler feed pumps, four in number were furnished by the Epping-Carpenter Company of Pitts-

burgh. These pumps are of the duplex outside and packed type, with cylinders 14 in. x 8½ in. x 16 in., designed for a capacity of 250 gallons per minute. The water cylinders and valve pots are of cast steel construction throughout.

The main piping system was furnished by the M. W. Kellogg Company of New York City. In the design of the high pressure steam piping, only the highest class materials were specified. The pipe flanges are all of wrought steel welded to the pipe. The fittings and valves are of cast steel, even down to the smallest sizes and of extra heavy construction. The boiler feed lines are also of welded construction throughout. The pipe lines are all laid out with long sweep bends to prevent expansion strains.

The boiler plant consists of six Babcock and Wilcox water tube boilers, having approximately 6,000 square feet of heating surface each. These boilers are equipped with double deck superheaters of the Babcock and Wilcox type, designed for superheating the steam 125 deg. F. The normal working pressure of the boilers is 210 pounds per square inch, the safety valves being set at 215 pounds. The boilers are of steel construction throughout, and designed for a safe maximum working pressure of 225 pounds per square inch.

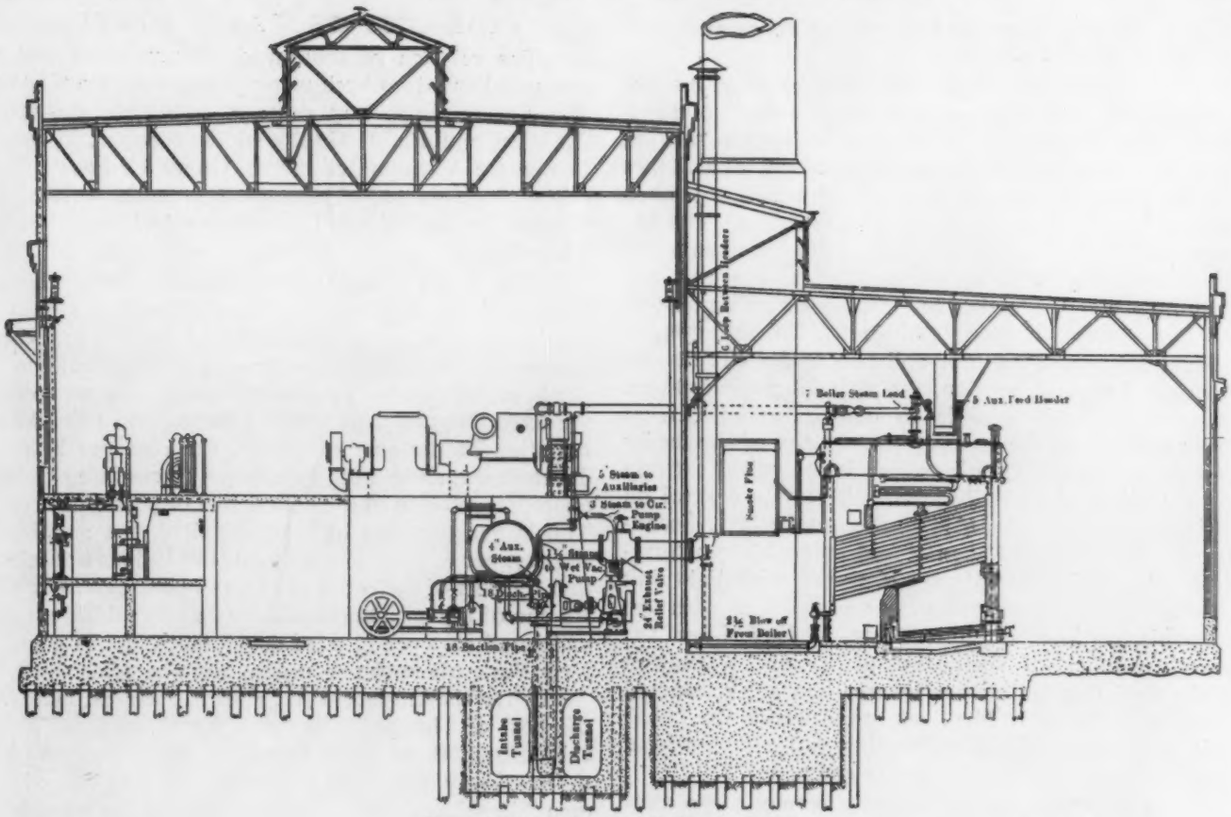
The fuel supply to the boilers is furnished through Hammel burners and furnaces. The furnaces are of unusual height, thus providing ample capacity for meeting the maximum demands of service. Four burners are provided in each furnace.

The fuel oil storage for the plant is maintained in a tank of 10,500 barrels capacity. A 10-inch suction line serves to connect the tank to the station. This line is installed in an insulated covering and is heated by a 1½ in. steam line to maintain the necessary fluidity of the oil.

Boiler Room of the Oakland Power Station.

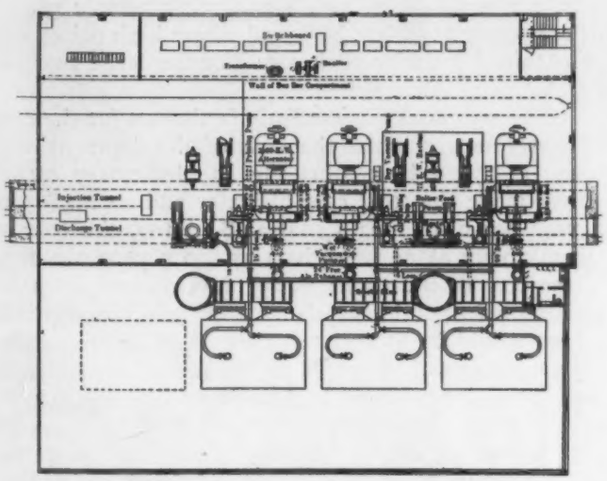
The arrangement of pumps, heaters, and piping for supplying and burning the fuel oil under the boilers is at once compact and very flexible in operation. The oil supply is maintained by two duplex 7½ in. x 5 in. x 6 in. Worthington pumps; the reheating of the oil being performed in two American standard coil feed water heaters, type A, rated at 250 boiler horsepower each. A 10 in. x 12 in. Gardiner Compressor driven by a 35 h. p. General Electric motor serves to supply compressed air for starting up the burners when the plant is not in regular operation.

The fresh water supply for the plant is secured from driven wells adjacent to the building, and from a connection with the city water mains. An elevated water storage tank of 25,000 gallons capacity serves



Cross Section of Oakland Power Station.

to maintain the supply during temporary interruptions to the service. The wells, which are 12 in. in diameter and 250 ft. in depth, have a capacity of approximately 6000 gallons per hour each. The water is pumped from the wells directly into the storage tank by means of a single stage air lift. The water supply to jackets of



General Plan of Oakland Power Station.

dry vacuum pumps, air compressor and turbine bearings is all conserved by being returned to a sump at one end of building. From this point the water is pumped back to the storage tank by means of a 2 in. motor driven centrifugal pump.

The circulating water for condensing purposes is supplied and discharged through a system of gravity tunnels. The supply tunnel leads from the estuary to the permanent end of the building, the discharge tunnel is parallel with the supply tunnel throughout the building portion, and connects with the shipping canal, discharging the water at the fartherest available point from the intake. The tunnels are constructed of reinforced concrete, and aggregate a total length of 1100 ft. The supply tunnel is provided with masonry gates at the intake and protected by racks and screens. The tunnels are of such dimensions and are located at such a level that they will supply an adequate amount of water for the condensers by gravity even at the season of extreme low tides.

The switchboard is of the remote control bench-board type and follows modern practice in its design. The board contains three generator, three exciter, one station, six feeder, one bus-sectionalizing and twelve instrument and relay panels, and is located on the main operating floor. From it are controlled the motor operated rheostats for the fields of the alternators, hand operated rheostats for exciter fields, motors for the turbine governors, and the 11,000 volt motor operated oil switches. In addition to the usual switches and indicating and recording instruments, the switchboard is provided with a complete set of indicating lamps, and mimic bus bars and switches, mounted on the face of the board. The connections of the various circuits can be indicated on the board by repeating the actual switching operations on the mimic outfit. For the direction of the attendants in operating, indicating instruments in parallel with those at the switchboard are located at each of the turbines and at each of the batteries in the boiler room. Communication between the turbines and switchboard is main-

tained through a system of speaking tubes and electrically operated signals.

The electrical current from the plant is distributed at the generator voltage, there being no transformers in the station except for the station service. The main generator leads connect through oil switches to the 11,000 volt power buses, from which are taken the feeder circuits controlled by oil switches. The 11,000 volt bus is installed in concrete compartments and is sectionalized with an oil switch between unit No. 2 and No. 3 and is further sectionalized with air disconnecting switches between each unit. The arrangement is such that one generator and two feeder circuits are connected to each section, the switching connections, however, make it possible to distribute the current from any one of the generators over any of the feeder circuits. The 11,000 volt system is controlled entirely by automatic electrically operated, remote control oil switches, and is equipped with the usual relays, disconnecting switches and current and potential transformers. The feeder circuits are equipped with lightning arresters of the multigap type and connect with the transmission line through ducts leading from the switch terminals to the outlets at the level of the top of the steel terminal tower where they are connected directly to the line. The lines connect with the 11,000 volt bus in the Oakland substation and with the local distributing system of the power company.

The power station has recently been put into commercial service, operating in parallel with the main transmission lines of the company. During periods of light load, the turbines are operated for their inherent ability to regulate the voltage of the system. The plant as a whole has shown its capacity for handling sudden and wide fluctuations of the load and maintaining normal operating characteristics.

Viele, Blackwell and Buck of New York are the engineers in charge of the design and construction of the Oakland Power Station, Sargent & Lundy of Chicago being retained by them as consulting engineers in connection with this work. The officers of the Great Western Power Company are as follows: President, Mr. Edwin Hawley, New York; Vice-President and General Manager, Mr. H. H. Sinclair, San Francisco; Secretary, Mr. H. P. Wilson, New York; Treasurer, Mr. F. M. Tompkins, New York.

Daylight development of photographic plates may be accomplished by placing any ordinary dry plate in a bath of potassium iodide after it has been exposed in the camera. This converts the silver bromide into a non-sensitive silver iodide. The plate should be laid for two minutes in a four per cent solution of potassium iodide, after which the development may be continued in subdued daylight, rinsing the plate for about five minutes before developing. The Chemiker-Zietung recommends the following developer, using equal parts of A and B. A: 600 gm. water, 20 gm. anhydrous sodium sulphite, 1 gm. metal, 1 gm. hydroquinone, 40 gm. potassium bromide. B: three per cent solution caustic potash. Fixing requires slightly longer time. The potassium iodide solution may be used many times but the developer should be mixed fresh for each plate.

THE COST OF WATER POWER.

The relation of cost of development to cost of power delivered for both water power and steam power is one of the important subjects discussed by Charles T. Main and F. M. Gunby in their paper, "Cost of Power for Various Industries Under Ordinary Conditions." This paper was read recently before the Boston Society of Civil Engineers and includes the following:

The cost of water power depends upon a great variety of factors, but the essential feature is usually the fact as to whether the combined result of all these factors is such as to make the cost of the development per h. p. delivered, a reasonably small amount, so that the fixed charges shall not be excessive. In the determination of the cost of power, the cost per h. p. of development should not be allowed to confuse or cause misrepresentation of the actual cost of power delivered. The larger the development installed, the smaller is the cost per h. p. of development, but it does not follow that the cost of delivered power will be smaller per h. p. As one of my assistants said, "The large development and small cost per h. p. of development looks good in New York where the securities must be sold."

After the engineers have made their estimates of the cost of physical structures for these modern developments, there must be added generous items for rights-of-way, and legal expenses, called by one of our men "illegal expenses." It is neglect of the consideration of a few things like this that has caused several of the recent developments to get into disrepute.

There is an idea common to some people that if a development will cost $100 a h. p. for the development, if carried to its most economical point, that it will be a safe investment, but when it reaches $200 a h. p. it will be well to proceed cautiously before investing any money in it. There are sometimes exceptional markets, for example, in mines and other remote places where power costs are high and where high prices can be obtained. Under such conditions, a large cost for development is warranted.

The estimates given a little farther on for the cost of water power when the cost of development was taken at $75 a h. p. plus the supplementary steam power make the total cost of water and steam $15.38 a year per h. p. With coal at $4 a ton, the cost of steam power alone was given as $20 a year per h. p. If the cost of the water power development is taken at $100 a h. p., the yearly cost of water and steam power would be $17.53. If the cost of the water developments was $150 per h. p., the yearly cost of water and steam power would be $22, which is more than the cost of steam alone with coal at $4 a ton.

As stated before for some particular uses, like mining, where there is no supply of wood, and coal is expensive, a high cost of development is warranted, and a high price can be obtained for the power. For example, there is one development in Mexico where the cost of power at the mines was from $150 to $200 a year, gold. A hydro-electric development was made and power delivered at $100 a h. p., this making a great reduction in cost to the mine owners and yielding a substantial profit to the electric company.

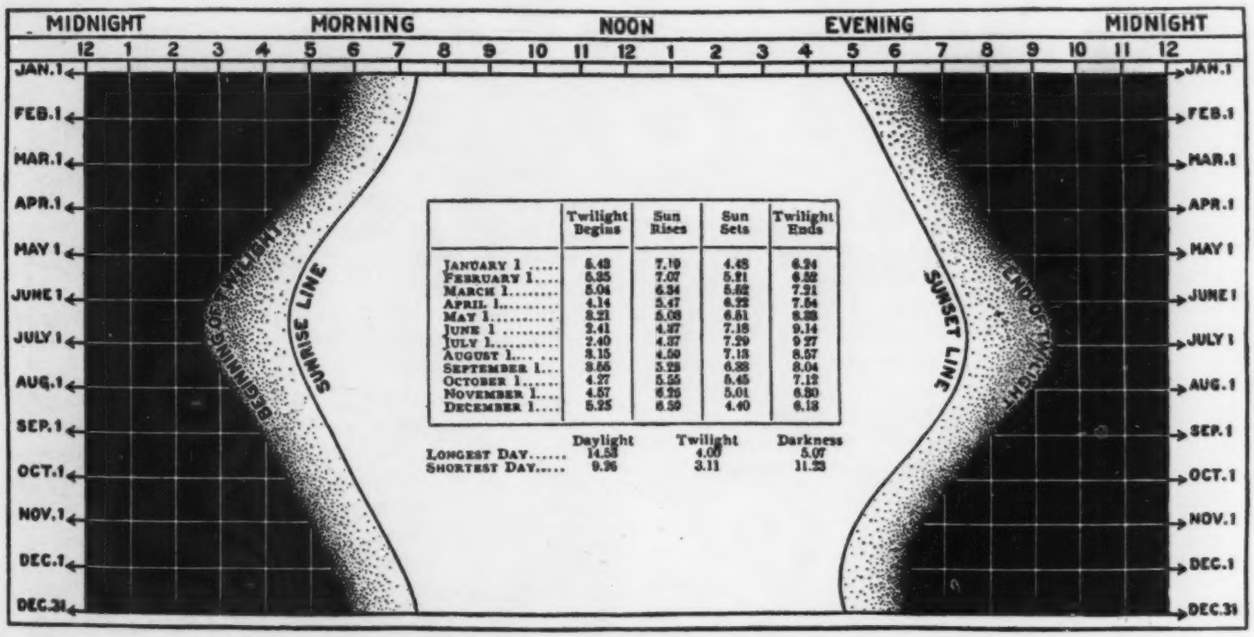
We once reported on a development in California

which cost about $400 a h. p. to develop. A small portion of this power could be disposed of at the mines for $75 a h. p. with comparatively short transmission lines, but the remainder had to be carried a long distance and sold in competition with other power. The fixed charges alone on this development were at least $30 to $35 a year, and the running expenses were also high. It was impossible to produce power cheaply enough to compete with other sources of powers and pay the fixed charges on the investment.

The value of a water power to various industries will vary in approximately the same ratio as the cost of producing power in some other way, if considered as power, pure and simple, without taking into consideration other important items affecting the business

capital to build it, which it had, than to purchase current brought over many miles of pole line, and be tied up to some foreign company.

The cost of power per k. w. at the switchboard from the hydro-electric company for the operating time of the mill was about $35 per k. w. per year; and for the steam plant which the mill was proposing to install, this cost was about $34 per k. w. year, but if the power had been bought from the hydro-electric company, the mill would have had to install and operate a boiler plant nearly as large as the one required for both power and manufacturing steam. It was estimated that the use of the waste products from the steam plant would reduce the net cost of the power at least $8 per k. w.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DEC.31
BEGINNING OF TWILIGHT
SUNRISE LINE
SUNSET LINE
END OF TWILIGHT
Twilight Begins | Sun Rises | Sun Sets | Twilight Ends
JANUARY 1 ..... 5.43 | 7.19 | 4.48 | 6.24
FEBRUARY 1..... 5.25 | 7.07 | 5.21 | 6.52
MARCH 1..... 5.04 | 6.34 | 5.42 | 7.21
APRIL 1..... 4.14 | 5.47 | 6.22 | 7.54
MAY 1..... 3.21 | 5.08 | 6.51 | 8.38
JUNE 1 ..... 2.41 | 4.37 | 7.18 | 9.14
JULY 1..... 2.40 | 4.37 | 7.29 | 9.27
AUGUST 1..... 3.15 | 4.59 | 7.13 | 8.57
SEPTEMBER 1... 3.56 | 5.28 | 6.38 | 8.04
OCTOBER 1..... 4.27 | 5.55 | 5.45 | 7.12
NOVEMBER 1.... 4.57 | 6.26 | 5.01 | 6.30
DECEMBER 1.... 5.25 | 6.59 | 4.40 | 6.18
Daylight | Twilight | Darkness
LONGEST DAY..... 14.53 | 4.00 | 5.07
SHORTEST DAY..... 9.36 | 3.11 | 11.23

Chart Showing Relative Duration of Daylight, Twilight and Darkness for Latitude of Washington, D. C., Denver and Sacramento. The twilight lines show the time for lighting and extinguishing lights in accordance with the Daylight Schedule.

which are sometimes more vital than the cost of power itself.

To illustrate the value and cost of power under different conditions, it may be well to mention two recent cases which we have passed upon. As consulting engineer for a hydro-electric company, we were asked to submit prices for electric power to a colored textile mill for which we were also engineers, and were engaged at that time in planning a new steam power plant for the textile mill. The price quoted was 1.2c per k. w. hour. As engineers for the textile mill, we were obliged to reply to ourselves as engineers for the hydro-electric company that we could not afford to accept the offer, the principal reasons being:

First—On account of the use of steam for manufacturing purposes and of the water of condensation for dyeing that the net cost of steam power would be less than the price of hydro-electric power.

Second—That it was better for the textile company to own and control its own plant, if it had the

The other case was where we were also making plans for a plain cotton mill for a new steam plant and where there were offers from two hydro-electric companies to furnish power. One offer was promptly turned down, asking too high a charge. A second offer was to furnish current at 1.2c per k. w. hour, which is the same price which we refused for the color mill. For a plain cotton mill, however, we concluded that it was proper to accept the offer at 1.2c per k. w. hour and there has been a contract signed for the delivering of the current.

The principal reasons for accepting this offer were:

First—1.2c per k. w. hour = about $36 a k. w. per year, or $27 an electric h. p. delivered. This reduced back to 1 h. p. equals about $23.50 per year, which was very near the estimated cost of steam power for the quantity required, and at the price of coal for this particular industry. Second—The mill desired to postpone the expenditure necessary for the steam plant if it could be done without serious loss.

THE MULTIPLE ARCH DAM.

BY C. E. GRUNSKY.

There are perhaps few engineers with experience in the construction of dams who have not at one time or another seriously considered the construction of a hollow concrete dam or weir. The question of how best to combine piers and arches in the construction of a multiple arch dam has therefore probably been under consideration many times. The writer is among those who took up this question some years ago but was not bold enough to suggest this type of dam even tentatively as a basis for cost estimates. He was never called upon to execute structures in connection with the project for which he had the multiple arch dam in mind and has found no occasion in subsequent experience to work out any specific problem. He wishes to commend the work recently done by Mr. John S. Eastwood—not with any special reference to the construction of this type of dam near Hume, in Fresno County, California,[1] but because Mr. Eastwood has ventured upon a departure which has merit.

It is not for a moment to be supposed that the multiple arch dam lends itself to use under all conditions. Like all dams that are of the type of a supported impervious skin it can only be used where a good contact between the skin—in this case the concrete of the arches—and an impervious foundation can be secured. If the foundation is lacking water will undercut the dam. In this respect such failures as that of the Hauser Lake dam (steel skin) in Montana, in 1908[2] and the undermining of the hollow concrete dam at Pittsfield, Mass., in 1909[3], may be recalled.

When however the dam can be erected on a solid bedrock foundation or upon a foundation suitably prepared and safeguarded against undercutting it will in many cases possess advantages over other types of structures making it worthy of consideration.

Mr. Eastwood's estimates of the thickness of the concrete which should be presented to water to prevent its percolation appear to be about right. It seems improbable that less thickness should be ventured then about as expressed by the formula

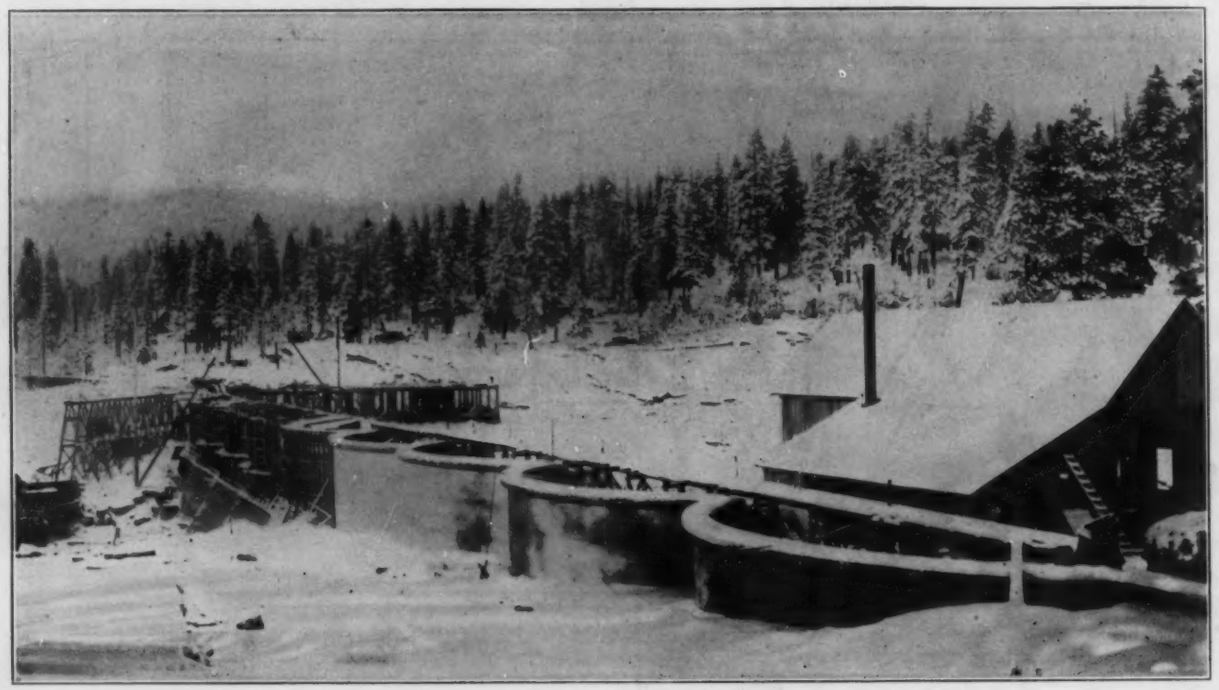
$$t = 1.0 + 0.05\,d$$

where t represents the thickness of the arch shells and d the depth below the water surface.

The thickness of the shell of the arch leads directly to the radius of curvature which should be adopted in order that all the concrete required to secure density be brought into adequate service. When it is further considered that the quantity of concrete required in the buttresses or piers as estimated from theoretical considerations is independent of their spacing it will be seen that the arches between piers may be sufficiently flat to keep their excess length over the pier spacing at a low value. The economical arch should not exceed materially 60 deg. For 60 deg. arches and shell thicknesses determined by the above formula for an allowable compression strees in concrete of 350 pounds per square inch and for heights of dams from 20 to 100 feet the pier spacing should not exceed limits about as follows:

For	h = 20	not	more	than	80 feet
"	h = 40	"	"	"	60 "
"	h = 60	"	"	"	53 "
"	h = 80	"	"	"	50 "
"	h = 100	"	"	"	48 ".

Apart from the masonry required to connect the arches with bedrock apart from the masonry for pier footings and apart from any additional masonry required to finish off the structure or to interconnect or



Front View of Hume Dam Showing Arches.

[1] Journal of Electricity, Power and Gas, Oct. 30, 1909.
[2] Engineering News, Apr. 3, 1908.
[3] Engineering News, Apr. 1, 1909.

stiffen the buttresses the quantity of concrete in the multiple arch dam is readily estimated.

The following table is based on an allowable compression stress in concrete of 350 pounds per square inch, on a minimum thickness of all concrete in piers and arches of one foot, on a shell thickness $t = 1.0 + 0.05d$ on a pier spacing (centre to centre) of 48 feet, on an arch radius (upper surface) of 48 feet, and on piers with down stream edge normal to the inclination of the face of the dam. All piers are treated as though submitting stress only along lines normal to the spring lines of the arches. In this theoretical consideration the pier thickness is assumed to increase at a uniform rate from the down stream edge of the pier to the toe of the dam.

The angles noted in the table refer to the slope of the face. They are the angles of the face with the horizontal.

Table:—Cubic feet of concrete in arches and piers (net) Per linear foot of multiple arch dam.

(Based on 350 lbs. per square inch as the allowable compression stress of concrete.)

Height of Dam.	THE ANGLE OF SLOPE.					
Feet.	30 deg.	40 deg.	45 deg.	50 deg.	60 deg.	70 deg.
10	30	24	22	21	19	19
20	78	63	60	56	55	56
40	240	195	185	180	175	185
60	510	420	400	385	390	410
80	890	740	710	690	705	750
100	1465	1230	1175	1145	1185	1275

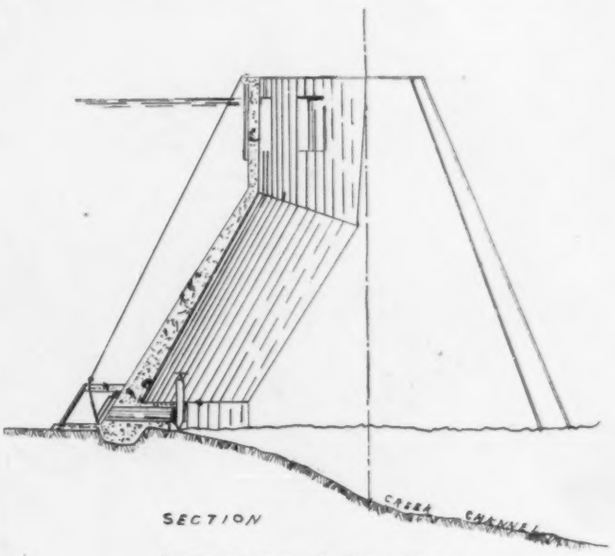
Ordinarily of course, depending upon local conditions, 20 to 50 per cent more concrete than noted in the table will be required for the connection with bedrock, for a modified disposition of concrete in the piers, for a possible interconnection of piers, for pier footings, and the like. The figures noted in the table are to be regarded as minimum figures based on theoretical considerations only, a fact to be regarded in making comparison with the amount of masonry required by dams of other types.

It will be seen that there is an economical position of the face. For high dams the face should make an angle of about 50 degrees with the horizontal. For dams less than 60 feet high it may be as steep as 60 which is practically the angle selected by Mr. Eastwood for the Hume-Bennett dam. But when the face is made steep the question of the shape of the pier or buttress is one for special consideration—a matter that need not be taken up in this general discussion.

Under favorable conditions the multiple arch dam should require only one-fifth to one-half of the masonry usually put into the ordinary solid masonry structure. The costs of the two structures do not, however, bear the same relation to each other as their masonry contents because, owing to the large amount of thin shell, to the curved forms required and to the extra good quality of concrete which must make the thin shell of the arches water tight, a much higher unit cost of concrete is to be anticipated for the new type of dam. In this respect the multiple arch dam is comparable with the various other types of hollow concrete dams which are usually built of reinforced concrete.

It is worthy of note as pointed out by Mr. Eastwood, that all parts of the dam are subjected to compressive stresses only. There is, therefore, no need of any reinforcement in any part of the structure. The use of a certain amount of steel, preferably in bars, which best resist disintegration by rusting and wearing away in case of water seepage along possible shrinkage cracks, is however advisable. This feature—the non-requirement of re-inforcement—should give the dam no small advantage over structures of the re-inforced concrete type whose life depending on the thoroughness of the protection of the steel against rusting, is more or less uncertain.

The disposition of the concrete in the piers is of course subject to much variation. One idea that suggests itself as appropriate in case of high dams is to assemble the concrete in a series of columns with arched openings between each two successive columns —the columns to be inclined to a position normal to the face of the dam.



Cross Section of Hume Dam.

The finishing of the top of the structure with short sections of arches standing vertically is a happy idea and is well illustrated by the work at Hume.

The dam at Hume as built by Mr. Eastwood departs in two essential particulars from true economical proportions. The vertical portion of the arches is unnecessarily high. There is no reason apparent why they were carried down 16 and even 20 feet. The arches as constructed cover about 120 degrees and therefore if properly planned, which is to be assumed, contain about 15 per cent more masonry than would have been required by arches planned for 60 degrees, for which of course somewhat lighter piers would have been set closer together.

Examination for engineer-physicist is announced by the United States Civil Service Commission on January 12, 1910, to fill vacancies in the position of engineer-physicist at $3,000 per annum or associate engineer-physicist at $2,000 to $2,500 per annum, in the Bureau of Standards. It is desired to secure persons who are fully able to initiate and carry on independent research in the field of engineering physics.

BUCKET SPACING ON TANGENTIAL IMPULSE WATER WHEELS.

BY S. L. BERRY.

In the following discussion of the design of impulse water wheels it is to be understood that there will be little or no reference to bucket shape. Although it is of great importance the subject will be brought up only when necessary to make clear the points aimed at.

The demand of late years for wheels of greater power and speed has produced conditions not liked by manufacturers, and it has been, and is, difficult to know just where the limit is to be found. It is hoped that the following diagrams and explanations will add something to the general store of knowledge on this interesting and important subject.

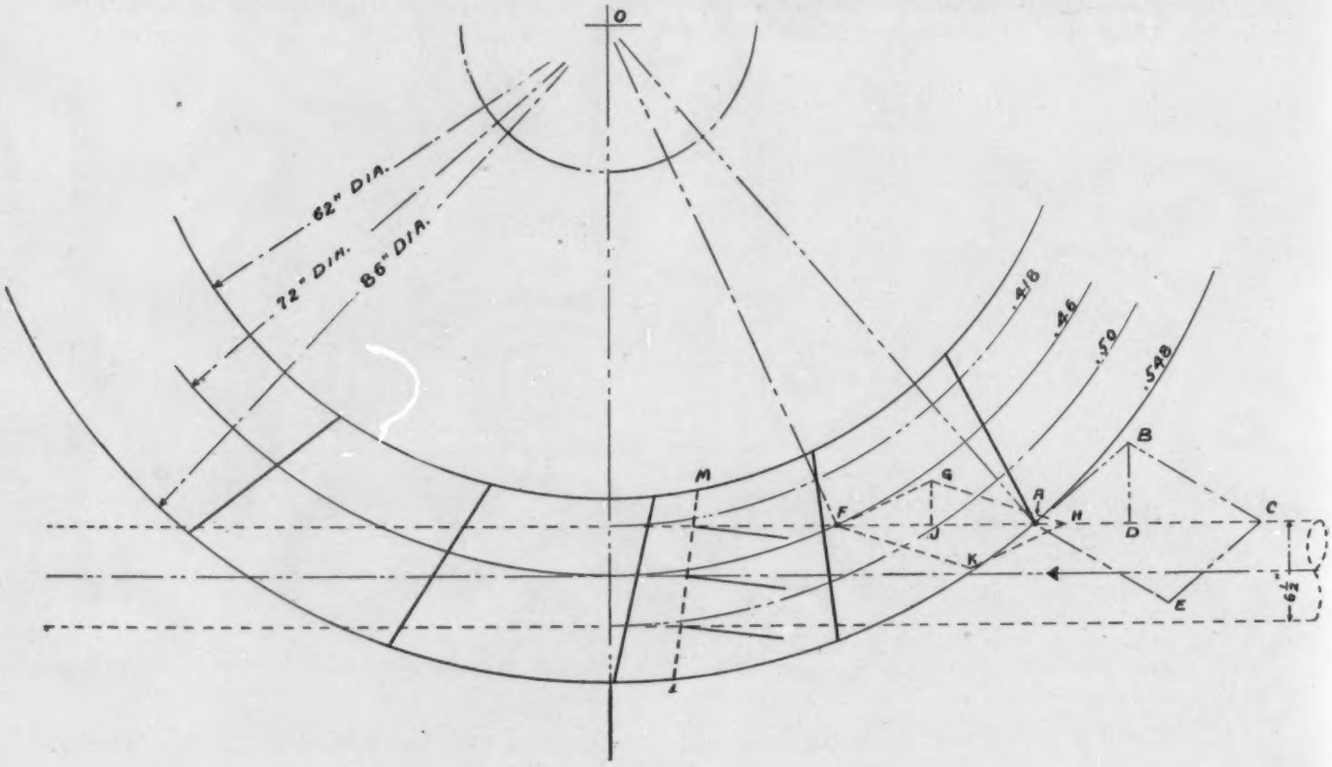


Fig. 1.

The dimensions of the wheel chosen for illustration are as follows:

Pitch diameter	72	in.
Outside diameter	86	"
Diameter to inner end of buckets	62	"
Diameter of jet	6½	"
Number of buckets	18	
Velocity on pitch circumference relative to spouting velocity	.46	
Diameter of leading circle	19½	in.

From these figures may be obtained the following velocities, relative to the spouting velocity, at the points mentioned:

Outer circumference of buckets	.548
Circle tangent to top stream line	.418
" " " bottom " "	.50

In Fig. 1 is shown the method of determining the direction of flow of the jet relative to the moving bucket. Let CA represent the direction and velocity of the top stream line, and BA the direction and velocity of the point A ($BA = .548\ CA$) then, completing the parallelogram, EA will represent the direction of flow of the top stream line relative to the moving bucket. Drawing BD perpendicular to CA, DA becomes the component of the velocity of the point A in the direction of flow of the water. The parallelogram $FGHK$ may be similarly constructed, by noting that the length of the tangent line GF becomes equal to $.46\ HF$. Then KF is the relative flow at the point F, and JF is the component of the velocity of the point F in the direction of flow of the water.

It will be noted that in these parallelograms if $HF = CA$ then $JF = DA$ and that $BA : GF :: AO : FO$ from which it follows that the velocity components, along the top stream line, will be the same for all points in the bucket at the instant when they cross that line. This is equally true of all other stream lines; that is, for each stream line there is a velocity component along that line which applies to each part of the bucket as it crosses that particular line. Advantage may be taken of this to simplify the work of finding the relative direction of flow at several points along the same stream line. The parallelogram may be constructed by drawing the tangent GF, making $HF = CA$ and $JF = DA$, then the perpendicular JG will locate the point G, it not being necessary to calculate the velocity of the point F, relative to the spouting velocity, a calculation which becomes tedious if often repeated.

By trial it may be determined that when the splitter reaches LM the relative flow of the top, center and bottom stream lines will be at right angles to the edge; this then being the point where the splitter is correctly inclined to the stream and produces no tendency to deflect it upwards or downwards, from its path. It

may be seen also, by inspection, that previous to this, in its movement, the splitter deflected the stream upwards by an amount which was greatest at the point of entry of the bucket into the stream and which decreased to the position *LM*. It will be admitted, even without diagrams, that the reverse will take place beyond *LM*, that the stream will be deflected downwards by an increasing amount as the splitter proceeds on its way. The significance of this action will be evident later.

Fig. 2 shows some results of a study of stream paths. Let *QRS* represent, in diagram, the inside of one-half of a bucket as they are ordinarily formed in section, and 2-3-4 etc., successive positions of the bucket. Divide the surface into a number of equal parts, and let *Q*-2, 2-3, etc., bear the same relation to the divisions of *QRS* that the bucket velocity bears to the velocity of the water over the surface of the bucket. Then, by transferring the successive points to the corresponding bucket positions, may be found the path of a particle of water which started through the bucket at *N*. This presupposes that the bucket section shown moves along the line *NT*, an ideal condition not found in practice, but it is only by an understanding of the simpler principles that the more complex can be applied.

It will be found in the case of *P*, where the bucket velocity is half that of the water, that the distance *SU* is equal to the length of the bucket section, and the same dimension in the other cases varies with the bucket velocity.

The final direction of flow in these diagrams corresponds with VV^1 etc., obtained in the usual manner. Let *SV* represent the direction and velocity of the bucket, VS^1 the direction and velocity of the stream in the bucket to the same scale, then VV^1 is the resultant direction and velocity of the stream in relation to the earth. The direction and velocity shown in this case are due to the angle of the discharge lip of the bucket combined with the effect of the slow speed of the bucket compared to the velocity of the water. At *U* may be seen the effect of the discharge lip angle only as in that case the velocities of water and bucket are such as would, in themselves, produce inert water.

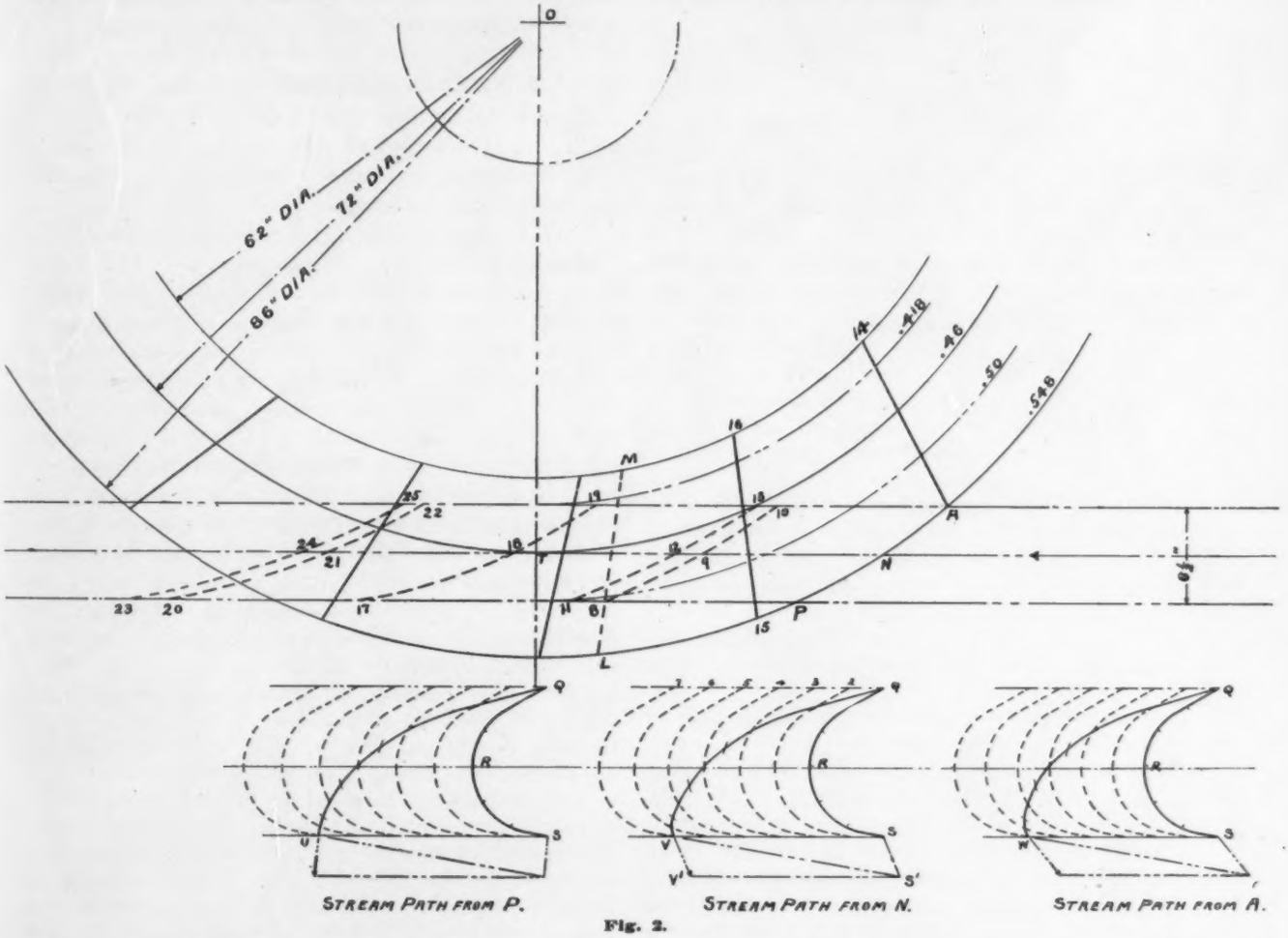


Fig. 2.

The application of the data from these three diagrams to the proper stream lines will produce the following lines:

8-9-10—where the first water reaches the bottom of the bucket.

11-12-13—where the first water reaches the discharge edge.

At the point *13* the first water to enter when the bucket reaches the point *A*, discharges, and the line represents the discharge points of the various stream lines cut by the bucket on its way through the stream.

The distance *A-13* equals *SW*, *N-12* equals *SV* and *P-11* equals *SU*.

Drawing *A-14* and *15-16* to represent the splitter of two buckets, it is apparent that the last water to pass under the bucket *A-14* must travel some distance to overtake the bucket *15-16*. The point at which this occurs may be approximately determined by the following formula:

$$D = \frac{A\,v}{1-v}$$ in which

D = distance bucket travels from position 15-16 measured along any stream line.

A = distance between buckets measured along the same line.

v = velocity (relative to spouting velocity) of points on the circle to which the same stream line is tangent.

For the conditions shown in Fig. 2 the formula is fairly close for the upper and central stream lines, but for the lower ones requires correction on account of the rapidly increasing angularity. This may be done by trial.

In Fig. 2 the line *17-18-19* represents the points at which the last water of the various stream lines overtakes the bucket, and making line *19-25* = *SW*
line *18-24* = *SV*
line *17-23* = *SU*
there results the line *23-24-25* of final discharge in the ideal bucket before mentioned, while *20-21-22* is where the last water reaches the bottom of the bucket.

It will be seen, by considering the relation of the line *17-18-19* to the outer circle of the buckets, that even were it possible to maintain the stream lines as shown, that is, without deviation up or down, the lower water is scarcely more than started on its way through the bucket when the two paths separate, and that for a part of the water it would be necessary to shorten the stream path.

This diagram shows that, for the proportions of wheel and stream given, eighteen buckets are not enough to allow all the water to be discharged along easy stream paths. With a straight splitter edge, inclined as shown, these conditions are worse in an actual wheel, for, as was explained in Fig. 1 all water reaching the splitter beyond the position of *LM* is deflected downwards and so reaches the outer bucket circle earlier than indicated in Fig. 2. Tracing this deflection is a difficult operation, but the diagram shows plainly the necessity for more buckets, and when worked out will form the basis for further study of the proper number.

As shown in Fig. 1 the line *EA* represents the direction of flow relative to the moving bucket, and the necessity for so constructing the entering lip, for a width at least equal to the diameter of the stream, that there will be no shock, makes it difficult to shape that part of the bucket to properly perform discharge functions. In other words that part of the bucket which must be designed especially for receiving the stream should not be required to discharge it. This means more buckets, and it appears that the greater part of the water should be discharged by the time the bucket reaches its lowest point.

This raises the question of friction loss due to the great increase in total bucket surface. It has been maintained that friction loss is in proportion to the total wetted surface, but what seems more probable is that, with the length of jet, per unit of time, fixed, it is immaterial whether it passes over one surface or the two halves pass over two, as far as friction loss is concerned.

The loss evidently depends upon the velocity of the water and the surface of the bucket passed over.

Whatever resistances to flow there may be which reduce the velocity will produce results less favorable than those indicated in the diagram, as the effect is the same as increasing the speed of the wheel, which delays the act of overtaking the bucket.

STEAM TURBINE ELECTRIC LOCOMOTIVE.

Consul J. N. McCunn of Glasgow gives the following brief description of the salient features of a new locomotive now in the experimental stage, an invention of a Scotch engineer:

At the opening meeting of the Glasgow University Engineering Society, October 28, 1909, Mr. Hugh Reid, managing director of the North British Locomotive Company, of Glasgow, in his address as honorary president of the society, made public a most interesting description of "the first steam turbine electric locomotive." This new type of locomotive is now under construction on the Reid-Ramsey system, in the works of the North British Locomotive Company.

The boiler in which the steam is generated is of the ordinary locomotive type, fitted with a superheater. Bunkers and water tanks at both sides of the boiler carry the coal and water supplies. A turbine of the impulse type, with a speed of 3,000 revolutions per minute, coupled directly to a continuous current, variable voltage dynamo or generator, receives the steam led from the boiler. The dynamo supplies electrical energy of from 200 to 600 volts to four series-wound traction motors, the armatures of which are built on the four main or driving axles of the locomotive.

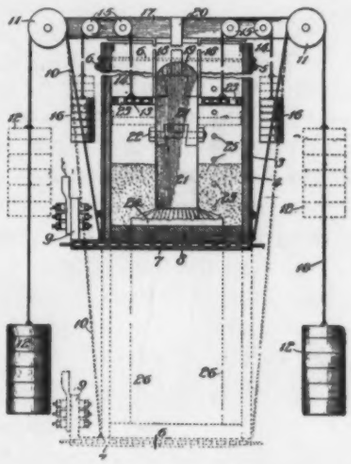
The exhaust steam from the turbine passes into an ejector condenser and is, together with the circulating condensing water, delivered eventually to the hot well. Owing to the fact that the steam turbine requires no internal lubrication, the water of condensation is free from oil and consequently is returned from the hot well direct to the boiler by means of a feed pump.

The locomotive boiler is deprived of the usual exhaust blast which induces the draft through the fire box and tubes, owing to the condensation of the exhaust steam. A forced draft, provided by means of a small turbine fan, replaces the reduced draft in the new locomotive. The fan is placed within the cooler so that it will deliver hot air to the boiler fire and at the same time assist the current of air through the cooler.

The small switchboard and the instruments required, the controller for grouping the four motors in series—series-parallel and parallel, according to the drawbar pull to be exerted—and the regulator for controlling the voltage in the electrical circuit and consequently the speed of the train, are all placed on the driver's platform within easy reach.

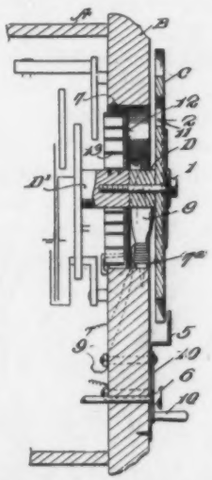
PATENTS

943,290. Electric Furnace. Charles E. Wilson, Hood River, Oregon. In an electric smelter for reducing ore containing ferro-tungsten, or a like refractory metal, the combination



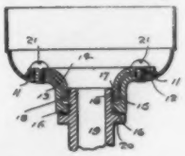
of a furnace formed with an electrode-carrying base and removable and replaceable sides, means for raising and lowering the furnace, and a stationary electrode extending downward into the furnace.

943,305. Illuminated Telephone-Dial. Rufus B. Halleck, Portland, Ore. The combination with a telephone instrument of the automatic type, the same being provided with a dial and a translucent indicator disk, the instrument being also



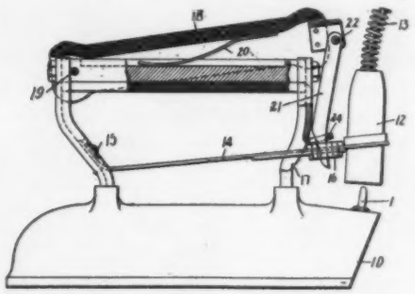
formed with a mortise, of a boss located centrally of the mortise at the rear side thereof, a spring secured to said boss and arranged to return the dial to normal position, a reflector disk secured to said boss in front of the spring, and a lamp interposed between the reflector disk and the rear face of the dial.

943,078. Means for Locking Electric Sockets to Fixtures. Harvey Hubbell, Bridgeport, Conn. Means for locking a socket to a fixture, comprising a cap having a flange, bushing members lying on opposite sides of said flange and having female threaded flanges, a male threaded hub engaging the flanges of the bushing and means for drawing the members of the bushing toward each other, whereby the flange



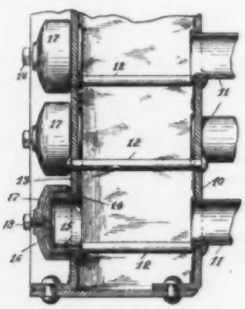
of the cap is clamped between the bushing members and the threaded flanges of said members are forced against the threads of the hub thereby locking the cap to the bushing and the bushing to the hub.

943,483. Electrically-Heated Tool. George E. Stevens, Lynn, Mass., assignor to General Electric Company. The combination with an electrically-heated tool, of a circuit controlling switch therefor arranged to be moved to operative



position when the handle of said tool is grasped, a device for latching said switch in operative position, and means whereby said latch is released when all the pressure is removed from the handle while permitting partial removal of the pressure without affecting the latch.

943,139. Water-Tube Boiler. Edward W. Clark, Los Angles, Cal. In a boiler, an outer plate, having holes opposite the tubes; short thimbles swaged into the holes in said outer plate and having the outer ends thereof exteriorly threaded and of larger diameter than the hole in the plate;



covers for the outer ends of said thimbles; cover caps screwed upon the ends of said thimbles; and tightening screws passing centrally through the cover caps and engaging the covers, the opposed faces of said covers and thimbles being faced.

JOURNAL OF ELECTRICITY
POWER AND GAS

PUBLISHED WEEKLY BY THE

Technical Publishing Company

E. B. STRONG, President
A. H. HALLORAN, Secretary and Managing Editor

DIRECTORS

R. J. DAVIS A. M. HUNT E. M. SCRIBNER C. L. COEY E. B. STRONG

604 MISSION STREET, SAN FRANCISCO

TELEPHONE - - - - - - - - - KEARNY 918

TERMS OF SUBSCRIPTION

United States, Cuba and Mexico	per year.	$2.50
Dominion of Canada	"	3.50
Other Foreign Countries within the Postal Union	"	5.00
Single Copies, Current Month	each	.10
Single Copies, prior to Current Month	"	.25

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Laws for the Engineer

A knowledge of law is as essential to the success of an engineer as in an understanding of mathematics. The man supervising a great electrical development devotes more time to signing contracts than to designing engineering details. By virtue of his position it is assumed that he is so familiar with these details that he can better utilize his experience in directing the work of others. In hiring men, in making contracts, in preparing specifications, there are certain legal requirements with which the engineer must be familiar. A mistake may involve him and his company in expensive litigation, which his legal information should have averted.

Corporations conducting work of any magnitude usually employ an attorney who passes upon all transactions involving legal matters. He does not possess the engineering ability to prepare the original contracts, but he can check their compliance with the dictates of the law. Most engineers take a pride in preparing documents in which the lawyer can find no flaw.

The comprehension of the law already indicated is no more than that necessary to any man of business. It is the accumulated fund of experience which governs all relations between men. Unlike engineering, law is not a systematized science. There is no single underlying legal principle, like the centimeter-gram second system, from which all others can be derived and explained. Nevertheless familiarity with the principle of the contract gives a clear insight into most of the requirements of the common law.

The law requires that contracts be in writing and of certain form. Neglect to put into writing an agreement between the Pikes Peak Hydroelectric Company and the city of Colorado Springs gave rise to a controversy as to what constituted a 2,000 c. p. lamp, and resulted in an award to the city, because the electric company substituted a 6.6 ampere, enclosed, alternating current arc lamp. Through custom, contract forms have become so standardized that a few model contracts and an appreciation of their essential parts are all that an engineer ordinarily requires. Some book on the subject of contract law is an indispensable part of an engineer's reference library. He should also be acquainted with the principles of corporation law, the law of right-of-way for pole lines and the law of accident indemnity. A hydraulic engineer must know the laws pertaining to water rights.

This does not mean that it is necessary to crowd a course in law into a college curriculum already too full. The supplementary after-reading which forms an invaluable adjunct toward acquiring that liberal education necessary for a man of affairs, should include a systematic study of the fundamentals of commercial jurisprudence. This should be thorough enough to enable the student to avoid trouble, but need not encroach on the lawyer's prerogative of getting him out of trouble, if he should be so unfortunate as to run counter to the law.

PERSONALS.

B. Smith, manager of the National Battery Company, is in San Francisco.

A. J. Myers, Pacific Coast manager for the Wagner Electric Company, is in Los Angeles.

George Westinghouse was elected president of the American Society of Mechanical Engineers on December 8, 1909.

W. J. Davis Jr., Pacific Coast engineer for the General Electric Company, returned to San Francisco this week from Los Angeles.

A. M. Irwin, assistant to the treasurer of the Westinghouse Electric & Mfg. Co., has returned to San Francisco from the North.

O. W. Lillard, manager of the Pacific Coast offices of the Gould Storage Battery Company, has returned to San Francisco from a trip to Salt Lake City.

W. R. Greene, formerly with the Los Angeles office of H. W. Johns-Manville Company, has joined the sales force of the Pacific States Electric Company with headquarters in San Francisco.

W. W. Briggs, manager of the San Francisco office of the Westinghouse Electric & Mfg. Co., is expected to return to San Francisco this week from a vacation trip to the Hawaiian Islands.

H. H. Seaman, the past two years manager of the Atlanta office of the Electric Storage Battery Company, has been appointed assistant manager of the New York electrical department of H. W. Johns-Manville Company.

TRADE NOTES.

The Seattle office of the John R. Cole Company has been moved from the Lowman Building to 416 American Bank Building.

The Southern California Edison Company of Los Angeles, Cal., has ordered six 100 k. v. a., 50 cycle, 10,000/2200 volt transformers for its power transmission lines from the Allis-Chalmers Company.

The San Francisco office of the General Electric Company report the sale of a 35 k. w. Curtis steam turbine generating set to the Lurline Baths; also a 25 k. w. set to the Standard Oil Company for installation at Newhall, Cal.

The Great Falls Water Power & Townsite Company at Great Falls, Mont., has bought six 200 k. v. a., 6600/2200 volt and three 150 k. v. a., 6600/440 volt transformers from the Allis-Chalmers Company to install at Black Eagle station, Montana, for power purposes.

The Panhandle Lumber Company will make extensive additions and improvements to their property at Ione, Washington, and have recently placed an order with Allis-Chalmers Company for considerable new equipment. This includes a turbo generator set which will furnish 600 k. w. at 80 per cent power factor, 480 volts, 60 cycles three-phase current when running at 3600 r. p. m. on 120 lbs. steam pressure and 28 in. vacuum. The condensers will be Allis-Chalmers type C with motor operated centrifugal pumps for cooling water and ejection. Excitation current for starting and reserve will be furnished by a 25 k. w. non-condensing turbo generator set and for operating a 22½ k. w. motor generator set will be supplied.

N. E. L. A. COMMERCIAL PROGRAM COMMITTEE MEETS.

The first meeting of the Commercial Program Committee of the National Electric Light Association, was held at the offices of Henry L. Doherty & Company on November 27th, to formulate plans for the next convention. There is a strong sentiment in favor of a curtailment in the length of the commercial program next year, so that the principal topics of interest may be taken up and discussed widely. With this in view, therefore, fewer papers will be presented, and no effort will be spared to bring out a thorough discussion from all members.

The committee will hold its second meeting in Chicago during the week of the Electrical Show, as the guests of H. M. Byllesby & Company.

NEW CATALOGUES.

The Chicago Pneumatic Tool Company have issued a booklet showing the advantages of the Franklin high speed air compressor, gas engine driven.

Catalogue K, Part 5, from the Gould Storage Battery Company, illustrates and describes couple types for railroad signals, fire alarm and telegraph work.

Bulletin No. 6 G, from the engineering department of the National Electric Lamp Association, is devoted to the Tungsten Street Series Lamps, covering the description, performance and economy of this lamp,

The Trumbull Electric Mfg. Co. of Plainville, Conn., are distributing notice of a novel prize competition of interest to electrical men. "Trumbull Cheer" for December is a Christmas number filled with bright sayings.

DEAN INTERCOMMUNICATING SYSTEM INSTRUCTION BOOK.

The Dean Electric Company of Elyria, Ohio, Kansas City and San Francisco have issued a booklet entitled "Intercommunicating System Instruction Book." This book is gotten up in suitable form to be easily carried in an overcoat pocket. The first section is devoted to the question of installation, and discusses the subject from the question of the location of stations, etc., to the testing out of the system, and putting it into operation. All of the points brought out are carefully illustrated, thus giving a clear understanding of the subject. The text as produced can be applied, in a general way at least, to any make of equipment. The Dean Company's system is used for illustrative purposes wherever such are deemed necessary.

The next section of the book is devoted to a chapter on the care of the talking and ringing battery. It is a well known fact that in operation of apparatus depending for power on dry cells, such equipment sometimes causes trouble, or show signs of trouble, if the dry cells were poorly installed and not cared for throughout. It is the intention of this chapter to dwell upon this point at considerable length, emphasizing the necessity of proper arrangement of cells and proper methods of wiring, etc. Suggestions are also made regarding the question of testing cells, and a list is given of the indications of battery trouble and possible remedies.

The next section of the books is entitled "A Few Cable Kinks." It deals with the question of switchboard cable construction, methods of determining cable lengths, methods of stripping cable, butting cable, waxing and soldering, completing forms, etc. This chapter of the book is valuable to anyone who handles such cables, whether they be used in intercommunicating systems or other types of telephone equipment. The points brought out are not new to most men handling switchboard cable. However, there is always a right and a wrong way of doing things, and the right way is the one developed in this article for handling such cases.

The last chapter in the book deals with the Dean intercommunicating system. It explains the methods employed in calling stations, how to answer a call, methods of trunking to central offices, and also takes up the question of the attendant's station, which is necessary to handle incoming calls. Taken as a whole, the little book contains the only printed matter ever written up in this form, which deals exclusively with the installation of intercommunicating systems.

NEWS OF THE STATIONARY ENGINEERS

PREAMBLE.—This Association shall at no time be used for the furtherance of strikes, or for the purpose of interfering in any way between its members and their employers in regard to wages; recognizing the identity of interests between employer and employe, and not countenancing any project or enterprise that will interfere with perfect harmony between them.

Neither shall it be used for political or religious purposes. Its meetings shall be devoted to the business of the Association, and at all times preference shall be given to the education of engineers, and to securing the enactment of engineers' license laws in order to prevent the destruction of life and property in the generation and transmission of steam as a motive power.

California.

No. 1. San Francisco, Thursday, 172 Golden Gate Ave. Pres., P. L. Ennor. Sec., Herman Noethig, 816 York St.

No. 2. Los Angeles. Friday, Eagles' Hall, 116½ E. Third St. Pres., J. F. Connell. Fin. Sec., Harry Notthoff, 1307 Winfield St. Cor. Sec., W. T. W. Curl, 4103 Dalton Ave.

No. 3. San Francisco. Wednesday, Merchants' Exchange Bldg. Sec., David Thomas, 914 O'Farrell St.

No. 5. Santa Barbara. Geo. W. Stevens, 2417 Fletcher Ave., R. R. No. 2.

No. 6. San Jose. Wednesday. Pres., W. A. Wilson, Sec., Lea Davis, 350 N. 9th St.

No. 7. Fresno. Pres., A. G. Rose. Sec., E. F. Fitzgerald, Box 651.

No. 8. Stockton. Thursday, Masonic Hall. Sec., S. Bunch, 626 E. Channel St. Pres., H. Eberhard.

Oregon.

No. 1. Portland. Wednesday, J. D. Asher, Portland Hotel. Pres., B. W. Slocum.

No. 2. Salem. A. L. Brown, Box 166.

Washington.

No. 2. Tacoma. Friday, 913½ Tacoma Ave. Pres., Geo. E. Bowman. Sec., Thos. L. Keeley, 3727 Ferdinand St., N., Whitworth Sta.

No. 4. Spokane. Tuesday. Pres., Frank Teed. Sec., J. Thos. Greeley, 0601½ Cincinnati St.

No. 6. Seattle. Saturday, 1420 2d Ave. Pres., H. R. Leigh. Sec., J. C. Miller, 1600 Yesler Way.

Practical letters from engineers and news items of general interest are always welcome. Write your items regardless of style. Communications should be addressed to the Steam Engineering Editor.

THE EXHAUST STEAM TURBINE.

By. J. G. De Remer.

The application of the modern steam turbine to low pressure or exhaust steam work was first made in this country about two and one-half years ago. As here designated the turbine is the last link in the chain of apparatus between the boilers and the condenser. It takes its steam either directly from the exhaust of the low pressure cylinder of the reciprocating engine, or from an intermediate receiver, or regenerator as it is called. In either form of application the pressure admitted to the turbine is usually very close to that of the surrounding atmosphere. The turbine of course exhausts directly into the condenser where the highest possible vacuum is maintained.

This simple use of a machine whose proven efficiency is not conspicuously better than that of the modern reciprocating engine seems at first thought, scarcely to possess features which warrant its rapid adoption. Let us look into the phenomena involved.

Reference to tables giving the properties of saturated steam shows us that when steam exhausts it does so in accordance with a definite law. The following pressure-volume curve shows this (Fig. 1). It will be seen that the rate of expansion for a given decrease in pressure is very small until the pressure falls below 30 lbs. per square inch (absolute pressure). From this point the volume increases faster and finally almost instantaneously jumps from 50 to 120 volumes with but a slight decrease in pressure. It will be noticed that the total area below the curve from the atmospheric pressure line (14.7 lbs. per square in.) to 1 lb. pressure is very nearly the same as that to the left of the curve and above the 14.7 lbs. line. theoretical indicator card has been drawn in, as represented by the section lining, to show that part of the entire available steam cycle which is used

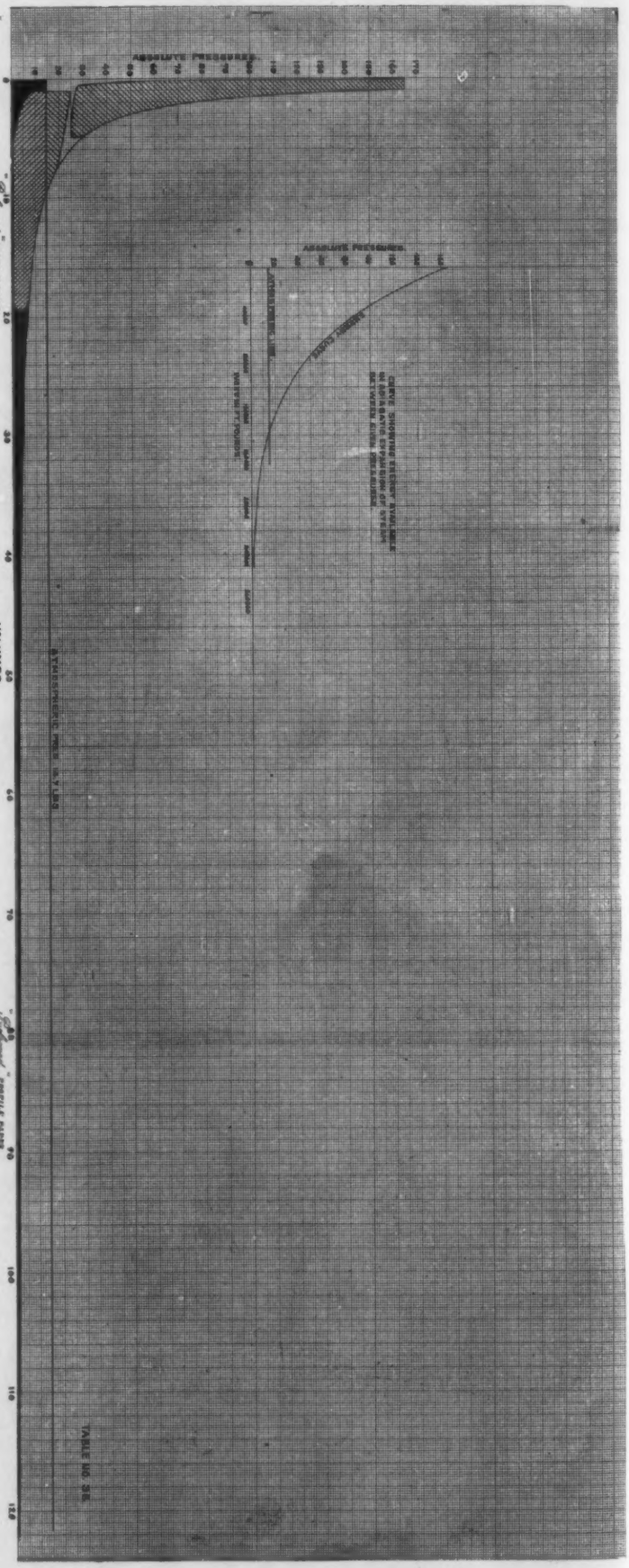


Fig. 1.

in a compound engine running condensing. It will be noted that the low pressure release takes place at about 6 lbs. absolute pressure which is the case with the average attained vacuum. The solid area of the card shows the additional relative work which the turbine does on this lower portion of the range. If properly designed the turbine will expand the steam right down to the condenser pressure. To accomplish this complete expansion in a reciprocating engine

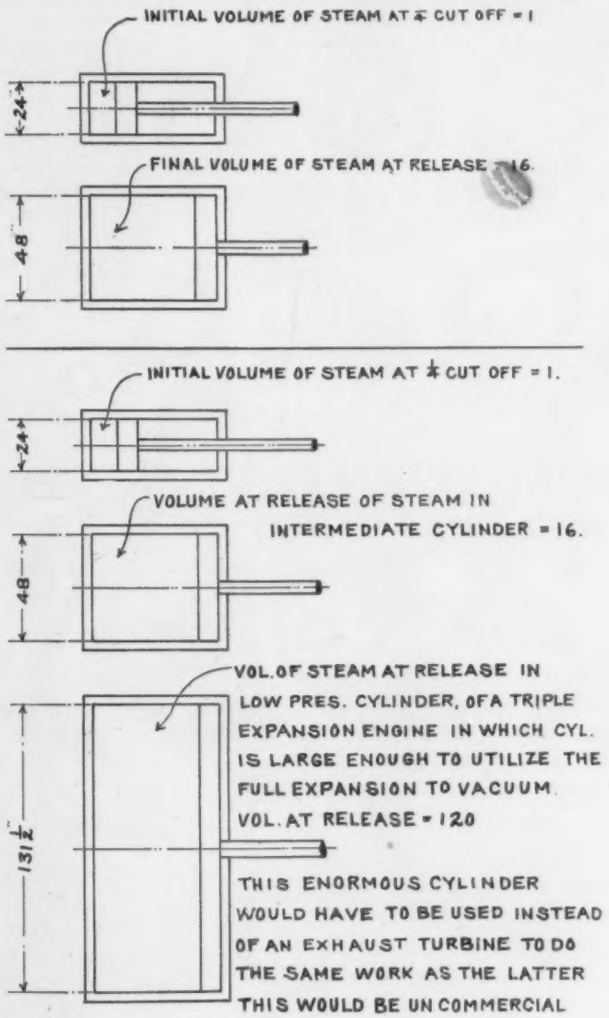

INITIAL VOLUME OF STEAM AT ¼ CUT OFF = 1
24
FINAL VOLUME OF STEAM AT RELEASE = 16.
48
INITIAL VOLUME OF STEAM AT ¼ CUT OFF = 1.
24
VOLUME AT RELEASE OF STEAM IN INTERMEDIATE CYLINDER = 16.
48
VOL. OF STEAM AT RELEASE IN LOW PRES. CYLINDER, OF A TRIPLE EXPANSION ENGINE IN WHICH CYL. IS LARGE ENOUGH TO UTILIZE THE FULL EXPANSION TO VACUUM. VOL. AT RELEASE = 120
131½
THIS ENORMOUS CYLINDER WOULD HAVE TO BE USED INSTEAD OF AN EXHAUST TURBINE TO DO THE SAME WORK AS THE LATTER THIS WOULD BE UNCOMMERCIAL

Fig. 2.

the low pressure cylinder would have to be so excessively large that it would be mechanically and commercially impossible to construct or operate. To illustrate this point consider the cylinders here shown (Fig. 2). The upper portion of the figure shows a 4-inch high pressure cylinder with volume at ¼ cut-off taken as 1. In the 48-inch low pressure cylinder the final volume of the steam would then be 16. This is sure to be slightly less than the final volume in the theoretical curve (Fig. 1.) The lower portion the figure shows the same conditions of expansion in high and intermediate pressure cylinders of dimensions similar to the above, but has an additional low pressure cylinder large enough to expand the steam out to 120 volumes, or to a 28-inch vacuum. The diameter of this cylinder is seen to be 131½ inches and its commercial construction would be out of consideration. With the turbine, however, the steam volume is increased as the pressure decreases and the discharge ports are even larger than the last stage of the cylinder so that the excessive volume of the steam is readily accommodated. It is therefore possible to utilize the full value of the condenser vacuum.

As was above stated the pressure volume curve in Fig. 1 is the curve of expansion for saturated steam. This gives a close approximation to the conditions which pertain in a piston engine. The alternate absorbing and giving up of energy from the cylinder walls tends to keep the steam in a saturated condition. In the turbine the expansion is more nearly adiabatic; that is, no heat is added or substracted externally during the expansion. This is due to the absence of cyclic changes. The temperature of the turbine cylinder walls diminishes gradually as the discharge end is approached. The energy curve in the upper part of Fig. 1 shows this adiabatic expansion of one pound of steam between the given pressure limits. It shows that the energy of expansion between 165 lbs. and 1 lb. pressure is almost divided by the atmospheric line. Of this amount the turbine is able to utilize for useful work nearly two-thirds while the reciprocating engine can make use of but from one-fifth to one-third.

There are two broad fields of application where low pressure turbines are coming into effective use. One is where the steam supply is intermittent or variable in quantity as in rolling mills or where factory processes are carried on with steam engines, steam hammers, hoists, etc. All of these involve the regenerative principle and require a careful study of the time element in supply and demand. The other application is that of augmenting or improving the efficiency of a given reciprocating engine plant. This may be occasioned by a desire to increase the plant capacity where the engine is of a good design and efficient; or there may be a possibility of bringing up the plant efficiency of a poorly designed installation. The importance of this latter possibility may be realized by considering some results that have been attained.

A plant of non-condensing engines of small size may be changed over to reduce its water rate from 30 to 35 lbs. per kilowatt hour to 15 or 18 lbs. per kilowatt hour; in other words from the same expenditure of coal and water a net increase in power of from 80 to 100 per cent may be realized, depending upon the size of equipment. In one instance a minimum water rate of 15.8 lbs. per k. w. hr. (150 lbs. dry saturated steam to 28 inches vacuum is obtained from an engine giving 28.5 lbs. per k. w. hr. now condensing and 20.5 lbs. per k. w. hr. condensing; an increase in rated capacity of 90 per cent. This is equivalent to 9.9 lbs. per indicated horsepower hour.

In addition to the marked economies to be effected the low-pressure turbine plant has certain other inherent advantages. During periods of light load the turbine may be cut out, the engine being connected directly to the condenser, and thus a fairly high economy obtained even though the whole plant be underloaded. If occasional even continuous deficiencies in the steam supply should occur, the turbine may be fed with live steam directly through a reducing valve to supplement the normal supply.

This subject, while being new to many engineers, contains latent possibilities, the utilizing of which will afford a valuable and highly interesting field of work for members of the mechanical engineering profession.

SAN FRANCISCO No. 1.

At our meeting of December 16th the various committees reported encouraging progress, more especially the smoker committee, who are making elaborate preparations for the smoker and house-warming which will take place Thursday evening, December 30th. Considerable interest is manifest by the members, as it is rumored that some of the members have something of a joke up their sleeves which they will escape on that particular evening. Something mysterious, represented by the letter X. We also had a visitor, Brother Goodwin of Los Angeles No. 2, who gave a good account of the work accomplished in Los Angeles and vicinity.

H. W. NOETHIG, Secretary.

INDUSTRIAL

THE 110,000 VOLT CIRCUIT BREAKERS ON THE LINES OF THE SOUTHERN POWER COMPANY.

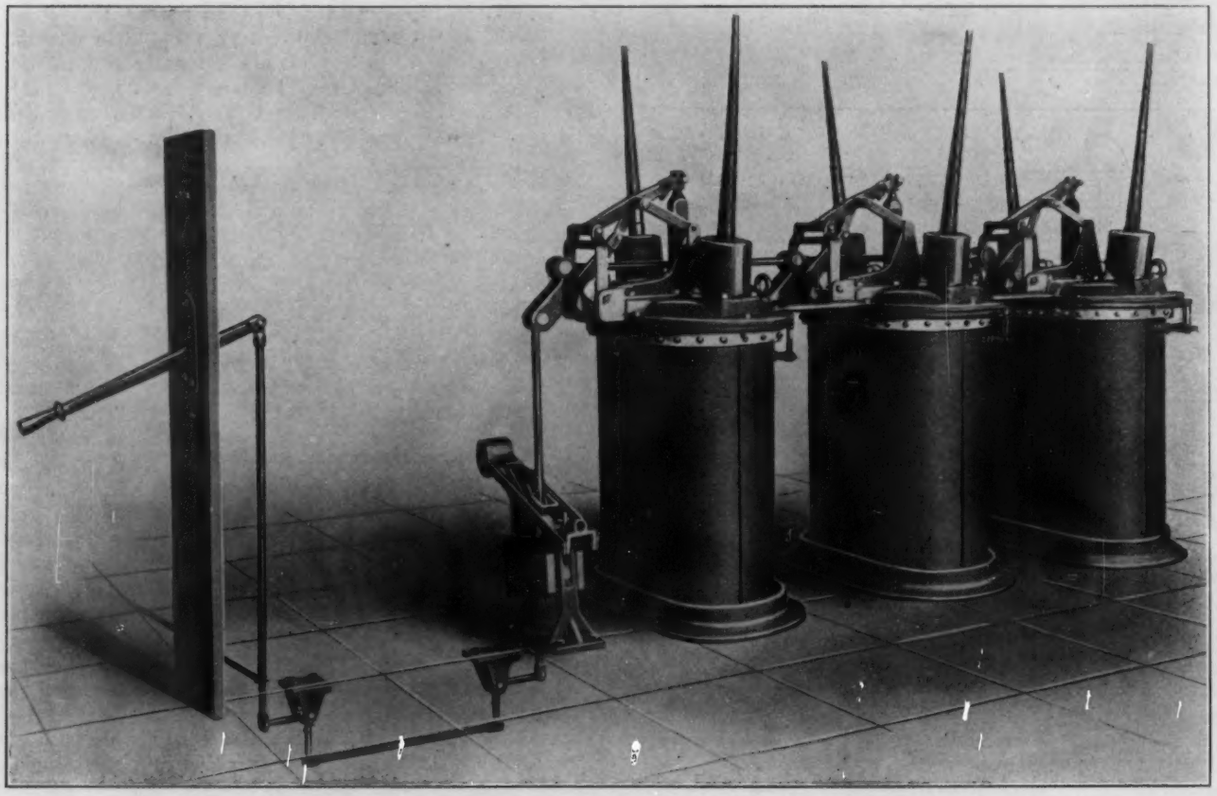
Four groups of 110,000 volt oil circuit breakers were recently put in service by the Southern Power Company on its high tension transmission lines in the vicinity of Charlotte, N. C. This installation is unique as being the first in which switching apparatus is called upon to break currents of this extreme potential, although several similar plants are now under construction and will shortly be in operation.

In the case of the Southern Power Company's lines not only is the voltage interrupted remarkable, but the magnitude of the currents being successfully handled under these severe conditions marks a long step in the design of high tension control apparatus. In this connection it is interesting to note the rated limit of operation of these 110,000 volt circuit breakers, viz.: that they shall successfully interrupt any short circuit that may occur on a transmission system of 120,000 kilowatts capacity.

As shown in the accompanying illustration, a feature of the construction of these circuit breakers is the isolation of each pole in a separate tank. Each pole is thus entirely independent of the others except for the pull rod which operates the contacts. This rod is released by the tripping mechanism shown at the left of the tanks, allowing the contacts to open by gravity. The 47-inch break thus interposed into each phase occurs in the center of the tank, in oil free from any possible sediment or moisture. By the arrangement of the operating mechanism, gravity assists in making a quick break during normal operation, while in case of any injury to the circuit breaker parts the circuits naturally tend to fall open—an important safety precaution.

A double break is made at each pole, spring seated butt contacts assuring a firm closure. A small double pole, double throw switch operated by the contact mechanism provides a simple tell-tale, indicating the position of the breaker contacts, by lighting a red or green lamp. The tanks are of welded seam boiler steel, filled with oil and fitted with a thick lining of specially treated insulation which encloses the contacts. The terminals are of the condenser type, and allow the line wires to be brought in directly from overhead.

The 110,000 volt breakers for the Southern Power Company are of both the hand and electrically operated types. They are normally closed by energizing the operating solenoid from a low voltage local circuit, but may also be hand operated by a lever handle through a simple mechanical connection. Series relays, mounted on suspension insulators and inserted directly in the line, are provided for automatically tripping the circuit breakers in case of overload. A wooden rod transmits the movement of the relay armature on the suspension insulator to the latch mechanism, providing a simple and quick acting mechanical release effected directly by the line current.

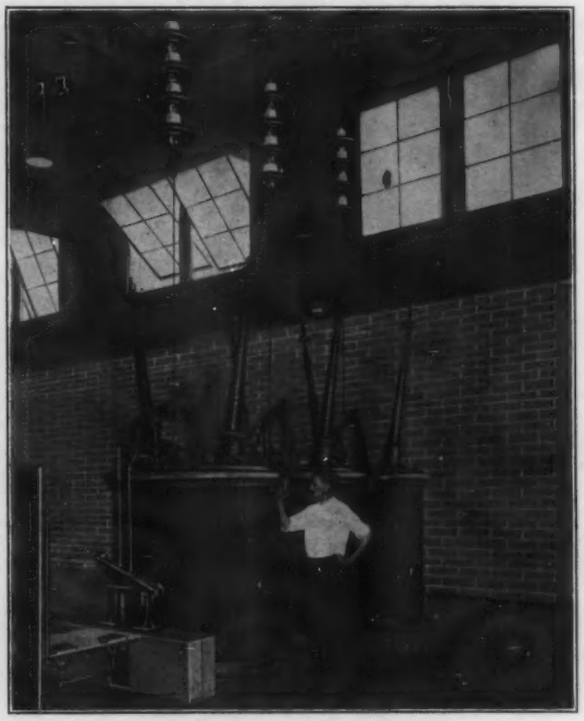


Hand Operated Type "GA" Westinghouse Oil Circuit Breakers with Built-in Series Transformers.

Fifteen breakers of type and construction similar to the 110,000 volt apparatus will also be installed by the Southern Power Company for controlling its 88,000 volt transmission circuits. These breakers will be electrically operated and have tripping coils energized from series transformers "built in" around the terminals and mounted as part of the tank case as shown in the accompanying illustration. This disposal of the series transformers contributes to the compactness and self-contained character of the breaker group, avoiding all external transformer or relay devices and wiring.

The 44,000 volt lines of the same company are controlled by five sets of breakers of form similar to the high voltage apparatus already described, but designed for operation at the lower voltage.

The 110,000 volt, 88,000 volt and 44,000 volt circuit breakers described in the foregoing are of the type "GA" design, developed and manufactured by the Westinghouse Electric & Manufacturing Company. Elsewhere than the Southern Power Company, these breakers are now in use controlling



110,000-Volt Westinghouse Type "GA" Circuit Breaker During Installation.

lines aggregating 200,000 k. w. capacity, and ranging in potential from 44,000 to 88,000 volts, in the plants of the Idaho-Oregon Power Company, Boise, Idaho; Spokane & Inland Empire Railroad, Spokane, Wash.; Niagara, Lockport & Ontario Power Company, Niagara Falls, Ont., and Societa Industriale Italiana, Milan, Italy, besides a number of installations yet incomplete.

OCCURRENCE AND PRODUCTION OF IRON ORES ON THE PACIFIC COAST.

BY FRED HESSE.

The production of iron ores on the Pacific Coast is at present almost exclusively confined to British Columbia and Washington, and even this is, of course, insignificantly small compared to that of the Eastern States. In British Columbia the iron ore produced by the Texada mine has been shipped to Irondale on Puget Sound and there reduced to pig iron of fairly good quality. This ore is a magnetite of the following representative analysis: Iron, 65.71 per cent; sulphur, none; phosphorus, .013 per cent.

There are a number of prospecting and developing operations in progress in British Columbia, and although nearly all the ores found are magnetite, good results are expected in the future, especially since in respect to transportation facilities, the known deposits are advantageously situated, being all within easy reach of the navigable waters of the inlets which indent the coast line.

The iron ores of Washington have proved of sufficient importance to be dealt with by the Geological Survey of that State, in a booklet by S. Shedd, professor of geology, University of Washington, published in 1902, from which the following is quoted:

"The iron ores of Washington are magnetites, hematites, limonites, or hydrous sesquioxide of iron, known commercially as brown hematite and mixtures of hematite and magnetite. The Snoqualmie Pass ores are the only true magnetites, while the Clealum, Hamilton, and a part of the Stevens county ores are mixtures of magnetite and hematite. The Jefferson county ores, and part of the Stevens county ores, are limonites or bog ores. In several other places in the State, the bog ores have been found in small quantities but they are of no commercial importance. The iron ore in Mason county is quite largely a hematite, but most of it is of very little commercial value. In the Clealum district there is some quite strong lodestone ore.

"One of the most important questions in connection with the commerical value of an iron ore is whether or not it is suited for the manufacture of Bessemer steel. This point is determined quite largely by the amount of phosphorous the ore contains, and the extreme limit has been placed at .05 per cent, for an ore that contains 50 per cent of iron. While it is true that perhaps the question of the amount of phosphorus is one of the most important ones, it is necessary, of course, that the ore should have iron enough to make it profitable to work it and that the amount of silica, sulphur and other impurities must be small enough so as not to injure it. The amount, however, of sulphur or silica allowable in a Bessemer ore is considerable more than that of phosphorus. It is a fact, gathered from analyses of ores from some of the different mines in the United States and Cuba, that most of the ores are non-Bessemer ores. These ores, however, are used for making the commoner grades of iron and would not bring a price in the market so high as the Bessemer ores."

Table of analyses of Washington iron ores show that they range in phosphorus from nothing to 1.09 per cent. As far as the per cent of phosphorus is concerned, a few of them, as far as other impurities also are concerned, would be classed as Bessemer ores, but the larger part would be non-Bessemer. In some cases where the silica is within the Bessemer limit, there is quite a large amount of alumina, and that in connection with the silica would probably exclude those ores from the Bessemer class. Some of the ores contain a high per cent of manganese and quite a number of them have from 7 per cent to 14.28 per cent, while in one instance as high as 42.58 per cent was obtained, so that some of these might be valuable for the manganese they contain, provided they occur in anything like large bodies.

As regards their per cent of iron, the Washington ores range from 28.48 to 68.54 per cent. In taking the samples for analyses, the intention was to get average samples, but as on all the properties, with one or two exceptions, very little work has been done, it was a difficult matter to sample systematically, and I presume the analyses show the per cent of iron to be a little above the average of the whole deposits. The analyses show that with the exception of a few samples from one particular locality, and which were known to be of no value as iron ores before the analyses were made, that very few of the ores have less than 35 per cent of iron and quite a good many of them have from 40 to 60 per cent.

JAPANESE GOVERNMENT BUYS MORE AMERICAN TELEPHONE APPARATUS.

Another telephone switchboard order from the far East has been placed with the Western Electric Company by the Japanese Department of Communications, the equipment being used to extend the service in the capital city of Tokyo. This board is standard equipment of the sort used by the "Bell" companies in this country and in general use abroad. It is a common battery switchboard of the most up-to-date type. The Western Electric Company recently contracted to supply the Chinese Government the equipment for the first two modern telephone exchanges in the Empire, to be located in the city of Pekin.

ARC LAMP ILLUMINATION FOR SHOPS.

With the development of the carbon enclosed arc lamp and its general commercial introduction for interior illumination, there has come about an important step in the artificial lighting of large interior areas. This type of lamp has produced an illumination which has enabled the eye to see better, and, therefore, has had a cheerful acceptance as a source of high efficiency in the actual production of light. Another, and probably the most valuable thing which the enclosed arc has accomplished is the practical demonstration of the importance and value of diffusion, and in bringing out the most basic fact of illuminating engineering, which is that the proper utilization of light is quite as important as its proper production.

Arc lighting practice has practically settled on indoor lamps using approximately five amperes and eighty volts at the arc for direct current and six amperes and seventy volts for alternating current. For high ceilings, with little obstruction, the above rating does very well; for low studded ceilings and rooms with objects throwing heavy shadows, enclosed arc lamps give better distribution and more even illumination with a rating of three amperes and eighty volts at the arc for direct current and four amperes and seventy-five volts at the arc for alternating current. Besides this, low voltage lamps should always be equipped with carbon of a smaller diameter, so that the light emitted from the crater tip, which is at white heat, may have a predominating effect.

For very low ceilings, the ordinary length carbon arc gives a somewhat uneven distribution of light, and to meet such conditions a short enclosed arc has now been developed and is being manufactured by the Western Electric Company to meet such demands. These short arcs are 20 inches over all, and have a life of from 80 to 100 hours, which makes them in every way adaptable to circuits which are already operating lamps of the ordinary type.

Next to the choice of an arc lamp for indoor lighting is the laying out of a lighting equipment. As already stated, the one principle to be observed in the economic and efficient operation of any lighting system is a proper utilization of the light. In order to determine the number of lamps for the lighting of any given area, it is not only necessary to know the exact area, height of ceilings and objects to be illuminated, but considerable attention should also be given to surroundings, because very frequently the color decorations and tinting of the walls play an important part.

The purpose of the cored carbon in alternating current lamps is, therefore, to decrease the arc resistance and permit the establishment of the current through the arc when the electromotive force of the arc is near its zero point.

The other type of lamp which is used for illuminating is a six-ampere, 110-volt series, alternating current type.

This lamp when not in service stands cut out, so that when the lamp is switched on and the current enters it a portion of the current is shunted through the starting resistance, thereby energizing the series magnets which open the path of current through the starting resistance. Since the entire current now passes through the series magnets, the carbons are separated and the arc established. When the voltage rises above normal the shunt magnet becomes more strongly energized and by bringing the cut-out contacts into engagement short-circuits the arc. The winding of the shunt magnets is such that by connecting the coils in series the lamp can be operated on 60-cycle circuits, while by connecting the coils in multiple the lamp can be operated on 125-cycle circuits.

An important consideration other than the ones already mentioned in the installing of the arc lamp is the estimating of the capacity for transformers which are used and the wiring of these transformers. The capacity of the transformers to supply constant potential alternating current arc lamps should be based upon the volt amperes required by the lamp and not by the watts. In this way the size of the transformer is obtained such as to operate most efficiently, and, therefore, enable the lamps to in turn operate with the desired effect. The wiring between transformers and lamps should be heavy enough, so that there is no excessive drop in voltage. Lamps require when starting a current of about 10 or 12 amperes, and too great a reduction of terminal voltage prevents the lamp from starting.

The installation at the Western Alabama Railway Shops is a typical arc lamp installation, using the latest types of the enclosed carbon arc lamp embodying the features as described. These lamps have been in service for some time, and burn with a regular trim of from 80 to 100 hours. The layout of the system was very carefully planned by the illuminating engineers of the Western Electric Company, which company also supplied the lamps and transformers.

TRANSFORMER FOR BELL CIRCUITS.

The transformer shown herewith is made by the Fort Wayne Electric Works, Fort Wayne, Ind., for the purpose of utilizing alternating current for operating electric bells, annunciators and similar low-voltage apparatus, to take the place of dry cells, which are oftentimes a source of more or less trouble. The transformer is built for 110-volt circuits, and has a secondary winding with taps brought out so as to obtain 4, 8 and 12 volts, depending upon the connections. In electric bell wiring frequently the bell wires are run along the floor and are apt to be short-circuited. For this reason the transformer is designed so that it will operate for several hours on dead short-circuit without danger of burning up. This feature makes the transformer valuable for this class of work. The efficiency of the device is quite high for

Transformer for Bell Circuits.

a transformer of this size. The core loss is said to be approximately 0.4 watt. The primary leads consist of two rubber-covered flexible cables brought out through an insulating piece, anchored inside the case to prevent injury to the winding, due to pulling of the leads. The secondary terminals consist of three binding posts giving three combinations of voltages. This is the maximum combination which can be obtained through this number of binding posts. The casing is of cast aluminum covered with a heavy coat of black japan, so that the transformer may be installed in places where the appearance of dry cells would be objectionable. There is an air space between the body of the case and the wall upon which it would be mounted. The core and coils are thoroughly impregnated and the same care and quality of material are said to be used as in the construction of the transformer as in large high-voltage transformers.

NEWS NOTES

FINANCIAL.

PASADENA, CAL.—Mayor Early announces that people will in all probability be called upon to vote for or against the purchase of systems of three local water companies on January 26th.

HOOD RIVER, ORE.—Sealed proposals for the purchase of $90,000 of five per cent water bonds for the city of Hood River, Ore., will be received by H. B. Langille, city recorder, from date of the notice up to the 15th of February, 1910.

FREEWATER, ORE.—Freewater has turned in fifty-four votes for the issuance of bonds to the amount of $16,000 for the construction of a water system. An engineer will be selected and the specification drawn up immediately.

DOUGLAS, ARIZ.—The City Council has passed an ordinance providing for the issuance of bonds of the city to the amount of $325,000 for the purpose of providing funds for acquiring the existing waterworks in this city and constructing additional waterworks for the city.

MYRTLE POINT, ORE.—The City Council opened bids on the $22,000 waterworks bond issue and the offering of S. A. Keane & Co. of Chicago was accepted, and it is now hoped that the city will have funds on hand for the necessary improvements so that pipe and other supplies may be ordered early in the new year.

SEATTLE, WASH.—A special election will be called by the City Council of Kent in the near future, at which the question of a bond issue in the sum of $23,000 will be submitted to the voters. A bonding company has offered to pay 96 for 6 per cent bonds for additional funds necessary to complete the water project.

LOS ANGELES, CAL.—At the annual meeting of the Riverside Water Company last week, it was brought out in the report of the President, Francis Cuttle, that the company contemplates increasing the bonded indebtedness in the coming year in order to make extensive improvements in the system and to refund outstanding bonds.

INCORPORATIONS.

INDIO, CAL.—Corona Mutual Telephone & Telegraph Company, capital stock $25,000, by J. B. Hooch, Andrew Lindberg and O. M. Grizzle, of Corona.

CHELAN, WASH.—The Brown Electric Company has been incorporated with a capitalization of $500,000, by George P. Brown.

KALISPEL, MONT.—Articles of incorporation have been filed for the Bitter Root Mountain Water Power Company with a capital stock of $100,000.

SEATTLE, WASH.—The Washington Oil Burner Company, capital $150,000 has been incorporated by Charles L. Barnett, Dan R. Harris and John G. Kenmonth.

OROVILLE, CAL.—Articles of incorporation were filed here December 15th by the Deer Creek Power Company, capitalized at $1,000,000, with place of business at Chico, and the Hammon Engineering Company, capitalized at $1,000,000, and with principal place of business San Francisco.

OAKLAND, CAL.—The People's Electric Light & Power Company have filed articles of incorporation in the County Clerk's office with a capitalization of $500,000. The directors are D. U. Toffelmier of San Leandro, J. H. Hornung, A. C. Sprout, F. H. Woodward and W. H. Spaulding, all of Oakland. It is generally understood that the Great Western Power Company have secured the contract for supplying power to this distributing company.

SALEM, ORE.—A $10,000,000 corporation has been organized in Arizona to build the Portland, Lakeview & Eastern Railway, from Portland through Multnomah, Clackamas, Marion, Linn, Crook, Klamath and Lake counties to Lakeview or some point on Goose Lake. The total mileage in Oregon is expected to be about 500. The incorporators named in the articles are William S. Dexter, Charles S. Elgutler, Edward S Robinson, James Burns and Sidney R. Rheinstrom, all of Omaha.

TRANSMISSION.

ARCATA, CAL.—Fifteen hundred inches have been claimed by W. C. Elsemore in Jacoby creek for power and domestic purposes in the city of Eureka.

WASHOUGAL, WASH.—C. W. Cottrel is reconstructing the dam which was washed out by the recent flood and from which power was to be secured to light this and other places.

HAMILTON, MONT.—It is announced that the Hamilton Light & Water Company will begin work soon on the new power plant to supply light for the city. The plant will cost $150,000

TUCSON, ARIZ.—The installation of a modern and up-to-date electric power plant costing thousands of dollars is reported to be included in the plans of the Helvetia Copper Company, for the immediate future.

AGUASCALIENTES, MEX.—The Chapala Hydroelectric and Irrigation Company will furnish this place with power and light. The power company will build their power line into this city within the next two years.

SAN FRANCISCO, CAL.—The right of way across the marsh lands owned by the University of California in San Mateo county has been granted to the Sierra & San Francisco Power and the Pacific Gas & Electric Company.

CHIHUAHUA, MEX.—The Mayo River Power & Land Company, capitalized with $5,000,000 has taken over power concessions on the Mayo river, which were acquired by W. O. Temple of Denver, Colo., and plan to build a series of dams for the development of power.

BRIDGEPORT, CAL.—Judge Costigan, a prominent lawyer and promoter of Colorado, has spent a portion of the week in Bridgeport. He is working on a large power project with a view to impounding the waters of all the valley streams at a point below the Stewart ranch and erecting a large dam and generating power for all the surrounding needs.

LOS ANGELES, CAL.—The Consolidated Reservoir & Power Company of Los Angeles will start work shortly on its system by which it will bring the water of the Whitewater River to irrigate lands adjacent to Banning. The intake of their irrigation ditch will be at a point in the San Bernardino mountains at an elevation of 7000 feet and at the confluence of three streams which make up the main stream of the river. The company has completed the final survey for a cement pipe line to divert the water for a distance of six miles. Five miles below the intake, at a point ten miles northeast of Banning, the company will put in its first power house for the development of electrical energy. The water will thence flow on for two miles to a point still nearer Banning. where the second power house will be erected. H. Edwin Moore, Los Angeles is president and W. B. Scarborough, Monrovia is secretary.

PORTLAND, ORE.—The Portland Railway, Light & Power Company, B. S. Josselyn, president, Portland, has worked out a scheme for the utilization of water power involving the construction of three new power plants on the Clackamas River, and one steam power plant in East Portland. The plan involves the expenditure of $5,000,000 in the next three years. The power sites involved have already been purchased and the deeds to them are in the hands of the company. Orders for the machinery to be installed in them have been placed with the large manufacturers of electrical machinery in the east and the actual work of building dams, sluicing away earth for buildings and dams and of clearing the power sites has already begun. The three plants on the Clackamas River are to be known as the Clackamas, the Morris and the Upper Clackamas Plants. The latter will have a reservoir seven miles long up the Clackamas River, while the dam will be 155 ft. high and 750 ft. long, and constructed of solid masonry. It is estimated that it will take 1,500 carloads of cement to construct it. Work on the site of this dam has been prosecuted for the last 14 months, the company sinking holes as far as 100 feet into the ground to test the nature of the soil and rock in the vicinity of the dam. The earth in the vicinity of this dam is to be sluiced off the present winter down to bedrock, and contracts for the construction of this plant have been let to Sellers and Ripley, the hydroelectrical engineers who built the first of the large power plants at Niagara Falls. The Cazadero line of the Springwater division of the O. W. P. will be extended to the new dam site three miles from the present terminus of the line at Cazadero.

ILLUMINATION.

LONG BEACH, CAL.—The City Clerk will receive sealed bids up to 8:30 a. m. December 27th for furnishing to the city electric lights for lighting streets, public building and places of this city.

SANTA BARBARA, CAL.—The business men on State street between Haley and De la Guerra streets, are perfecting plans for the construction and operation of a co-operative electric light plant for their own use.

SALEM, ORE.—In order to eliminate all danger of fire in the penitentiary from exploding lamps every cell in the institution is to be illuminated with electric lights. Governor Benson has appropriated money to pay for the installation of the lights.

SEATTLE, WASH.—Ordinance No. 22664 has been passed by the City Council, directing the City Comptroller to advertice for the sale of negotiable bonds of the City of Seattle in the sum of $200,000 or bonds in the sum of $800,000, as authorized at the election held on the 29th of December, 1908.

CANYON CITY, ORE.—The electric lights have been out owing to the fact that the boiler at the light plant was burned out and will be out until the boiler can be repaired. The company has recently been re-organized and the president J. S. Marks states that it is the intention to put the plant in a first class condition.

TACOMA, WASH.—The failure of one supply company to enclose full specifications, in the opinion of Commissioner of Public Works H. J. McGregor, with its bid for $25,000 worth of incandescent lamps, have prevented awarding a contract and will necessitate laying the eight bids made, seven of which are identical, before the City Council for decision.

PHOENIX, ARIZ.—At a meeting of the City Council action was taken looking toward the establishment of a municipal electric lighting system. Estimated cost of plant is from $200,000 to $300,000. The City Council put itself on record in favor of a resolution introduced by Councilman Cisney, instructing the City Attorney to take steps toward obtaining permission from Congress for the city to bond itself for $300,000 for construction of a municipal lighting plant.

SANTA BARBARA, CAL.—Chairman J. N. Miller of the city water works commission system that a hydroelectric and light plant and a distributing system of wires or poles for supplying the city with electricity could be installed by the city in Mission canyon at a total cost of $100,000. The plans will be worked out to such a purpose if the people want the plant.

OAKLAND, CAL.—Negotiations by the National Electrical Lamp Company for the purchase of a block of land in West Oakland lying between Peralta and Campbell, and Sixteenth and Seventeenth streets have been completed. It is the purpose of the company to erect a fine factory on the new site. The regulation solid brick buildings in use at other points will be put up here, and a special force of men have been brought out from Marlborough, Mass. Work will begin next month.

PRINCE RUPORT, B. C.—The Grand Trunk Pacific road is fitting up a temporary electric plant on the wharf to supply its office buildings with light until the old plant at Seal Harbor, recently destroyed by fire, has been rebuilt. The Board of Trade has been agitating the installation of a civic plant, but it is more likely that Columbia Tie & Timber Company's sawmill at Seal Harbor will be rebuilt at once and a larger lighting plant installed in connection with it.

TRANSPORTATION.

ASHLAND, ORE.—John R. Allen has applied for a franchise for a street railway power line.

MISSION CITY, B. C.—It is reported that the Stave Lake Power Company is behind a scheme to build a tram line from Vancouver through this place.

OLYMPIA, WASH.—The Olympia Light & Power Company has made a proposition to extend the street car line across the Des Chutes channel and give the Westlake a street car system.

NELSON, B. C.—Alex. Carrie, the architect, has been authorized to call for bids for the construction of a substation and car barn for the Nelson Street Railway Company. The barn will be 28x80.

SAN DIEGO, CAL.—A permit in the sum of $100,000 has been taken out by the San Diego Electric Railway Company, for the erection of the proposed reinforced concrete car barns on Fifteenth between L and M streets.

RIVERSIDE, CAL.—The announcement has been made that the Crestmore Valley line is to be extended to Bloomington and that a franchise will at once be asked for from the Supervisors of Riverside and San Bernardino counties.

STOCKTON, CAL.—The work of building the Stockton Terminal & Eastern Railroad, connecting Stockton with the rich farming country to the east, with a terminal at the rock quarries above Jenny Lind, a distance of 28 miles, has begun.

PENDLETON, ORE.—Charles Hill, representing the Farmers' Mutual Railway is negotiating with the Commercial Club with a view to having his company build and operate an electric line between Umatilla and Holdman, a distance of about 25 miles.

LOS ANGELES, CAL.—The construction of an extension of the West Adams car line between the present terminus at Arlington and West Adams streets and Eleventh and West Adams streets will be begun immediately and will be completed in about two months.

MODESTO, CAL.—The first spike has been driven on the interurban line between Empire, on the Santa Fe, and this city. T. K. Beard, president of the road, says that the work will be rushed to completion as soon as possible and that the company expects to run cars by the middle of January.

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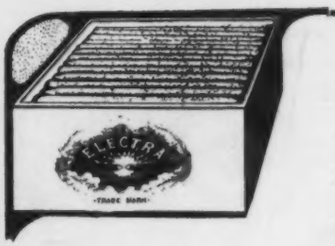

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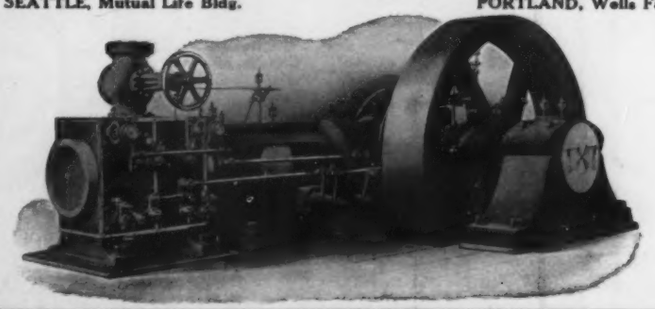

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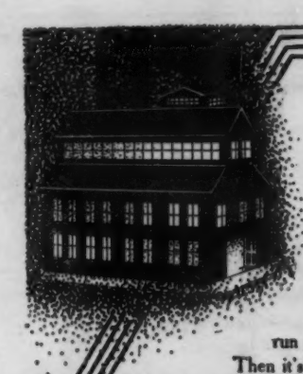

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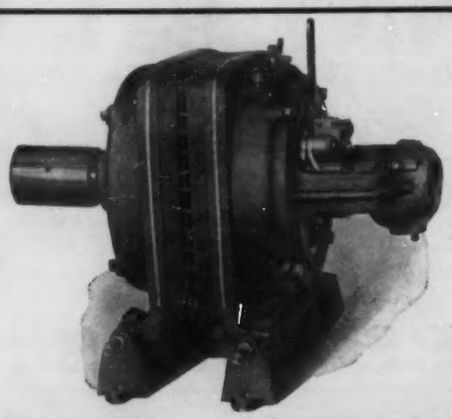

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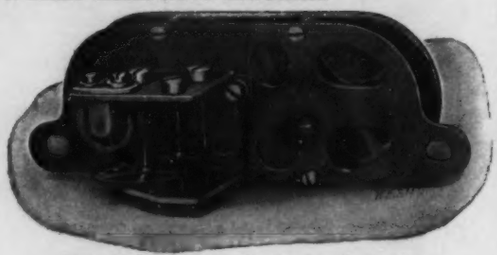

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Boston, 925 Old South Building.
Chicago, 1530 Monadnock Bldg.

Electric Goods Mfg. Co. .....
Boston, Mass.
San Francisco, 165 Second.

Electric Storage Battery Co. .....
Philadelphia, Pa.
San Francisco, Crocker, Blg.

Eureka Electric & Eng. Co. 9
San Francisco. 158 Fifth.

F

Fort Wayne Electric Works 4
Fort Wayne, Ind.
San Francisco, 604 Mission.
Seattle, Colman Bldg.

G

General Electric Co. 12
Schenectady, N. Y.
San Francisco. Union Trust Bldg.
Los Angeles, Delta Bldg.
Seattle, Colman Bldg.
Portland, Worcester Bldg.

H

Habirshaw Wire Co. .....
New York, 253 Broadway.

Harvard Electric Co. 9
Chicago, Ill.

Henshaw, Bulkley & Co. 1
San Francisco, 19 Fremont.
Oakland, 1436 5th.
Los Angeles, 262 S. Los Angeles.

Hughes & Co., E. C. 9
San Francisco, 147 - 151 Minna.

Hughson & Merton .....
San Francisco. 544 Van Ness Ave.

Hunt, Mirk & Co. 6
San Francisco, 141 Second.

I

Indiana Rubber & Ins. Wire Co. 1
Jonesboro, Indiana.

J

Johns-Manville Co., H. W. .....
New York, 100 William.
San Francisco, 159 New Montgomery.
Los Angeles, 203 E. 5th.
Seattle, 576 1st Ave. So.

K

Kellogg Switchb'd & Supply Co. ..
Chicago.
San Francisco, 88 First.

Kierulff, B. F. Jr. & Co. .....
Los Angeles, 120 S. Los Angeles.

Klein, Mathias & Sons 3
Chicago, Station U, 29.
San Francisco, 155 New Montgomery.

L

Lindsley-Wright Co. .....
Portland, Ore.. 336 Sherlock Bldg.

Locke Insulator Mfg. Co. .....
Victor, N. Y.
San Francisco, Monadnock Bldg.
Los Angeles, Pacific Electrical Bldg.
Seattle, Colman Bldg.

M

Moore, C. C. & Co., Inc. 3
San Francisco, 99 First.
Los Angeles, Trust Bldg.
Seattle, Mutual Life Bldg.
Portland, Wells-Fargo Bld.

N

New York Insl'td Wire Co. .....
New York, 114 Liberty.
San Francisco, 770 Folsom.
Seattle, Lowman Bldg.

O

Ohio Brass Co. .....
Mansfield, Ohio
San Francisco, Monadnock Bldg.
Los Angeles, Pac. Electric Bldg.
Seattle, Colman Bldg.

Okonite Co. 1
New York 253 Broadway.

P

Pacific Electric Heating Co. .....
Ontario, California
Chicago, 558-560 Washington Blvd.

Pacific Meter Co. 1
San Francisco, 301 Santa Marina Bldg.

Pacific Telephone & Telgrh. Co. ...
San Francisco, Shreve Bldg.

Paiste Co., H. T. 3
Philadelphia, Pa.

Parrott & Co. 4
San Francisco, 320 California.
Los Angeles, Citizens' National Bank.
Portland, Ore., Portland Trust Co. Bldg.
Seattle, Globe Block.
Tacoma, 514 Bank of California Bldg.
Spokane, 161 S. Post.
Honolulu.
Guatemala.

Partrick Carter & Wilkins Co. ....
Philadelphia, 22d and Wood.

Pelton Water Wheel Co., The 2
San Francisco, 1095 Monadnock Bldg.

Perkins Elec. Switch Mfg. Co., The
Bridgeport, Conn.
San Francisco, 609 Mission.

Phillips Insulated Wire Co. 1
Pawtucket. R. I.

Pierson, Roeding & Co. 4
San Francisco, Monadnock Bldg.
Los Angeles, Pac. Electric Bldg.
Seattle, Colman Bldg.

Popular Electricity Pub. Co. 2
Chicago, 1212 Monadnock Block.

Portland Wood Pipe Co. 9
Portland, Ore.

R

Reisinger, Hugo 3
New York, 11 Broadway.

S

Schaw-Batcher Co. Pipe Works ..
Sacramento, Cal., 211 J St.
San Francisco, 356 Market.

Simplex Elect'l Co., The 3
Boston, 110 State.
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Simplex Electric Heating Co. .....
Cambridge, Mass.
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Southern Pacific Co. 5-14
San Francisco, Flood Bldg.

Sprague Electric Co. 12
New York City, 527-531 W. 34th.
San Francisco, Atlas Bldg.
Seattle, Colman Bldg.

Standard Electrical Works 2
San Francisco, 669 Mission.

Standard Engineering Co. .....
San Francisco, 503 Market.

Standard Und. Cable Co. 1
San Francisco, First National Bank Bldg.
Los Angeles, Union Trust Bldg.
Seattle Office, Lowman Bld.

Star Porcelain Co. 9
Trenton, N. J.

Sterling Paint Company, ... 9
San Francisco, 118 First.

T

Technical Book Shop 13
San Francisco, 604 Mission.

Tel. & Elec. Equip. Co. 3
San Francisco, 612 Howard.
Los Angeles, Security Bldg.
Seattle, Alaska Bldg.
Portland, Couch Bldg.

Thomas and Sons Co., R. .....
New York, 227 Fulton.
East Liverpool, Ohio.

Thompson & Co., Chas. C. .....
Chicago, 338 Wabash Ave.

Tracy Engineering Co. 9
San Francisco, 461 Market.
Los Angeles, Central Bldg.

V

Vulcan Elec. Heating Co. .....
Chicago, 546 West Jackson Blvd.

Vulcan Iron Works 1
San Francisco, 604 Mission.

W

Western Electric Company 2
San Francisco, 680 Folsom.
Oakland, 507 16th.
Los Angeles, 119 E. 7th.
Seattle, 1518 First ave. So.

Westinghouse. Elec. & Mfg. Co. ... 6
Pittsburg, Pa.
San Francisco, 165 Second.
Los Angeles, 527 S. Main.
Seattle, 314 Central Bldg.
Portland, Couch Bldg.
Spokane Columbia Bldg.

Westinghouse Machine Co. 6
Pittsburg, Pa.
San Francisco, 141 Second.

Weston Elect'l. Instrument Co. 14
Waverly Park, N. J.
New York, 114 Liberty.
San Francisco, 682 - 684 Mission.

Wilbur, G. A. 9
San Francisco, 61 Second.

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The rate for advertisements in this column is $1.00 per insertion for 25 words or less; additional words 2 cents each, payable in advance. Remittance and copy should reach this office not later than Monday noon for the next succeeding issue.

Replies may be sent in care of the Journal of Electricity Power and Gas 604 Mission Street, San Francisco.

WANTED—Second-hand, single-phase, 133-cycle alternator, 75 to 90 k. w., Stanley preferred, for early summer 1910 delivery. Montesano Light and Water Co., Seattle, Wash. 1-22

WANTED—Meter testers to send for our new meter-testing book, giving full information on connecting and testing meters. This book, sent free upon request, will enable you to increase the efficiency of the meter department. Central Electric Co., Chicago, Ill. 1-1-10

FOR SALE—An electric wiring and supply business in a progressive California town of 2500 population; no competition; $5000 gross annual income; price $1000. Box 25, **Journal of Electricity, Power and Gas,** San Francisco. 1-8

SEVERAL months work for a Mechanical Draughtsman familiar with Power Plant Steam Piping. Address Box 60, **Journal of Electricity, Power and Gas.** 12-25

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604 Mission Street, San Francisco.

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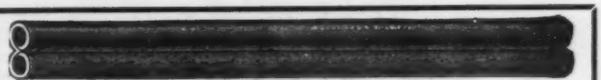
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Partrick,Carter&WilkinsCo.
Western Electric Co.

Storage Batteries

Elec. Storage Battery Co.
Westinghouse Machine Co.

BELLS

Electric Bells

Elec. Goods Mfg. Co., "Victor," "Dandy," "Tyrolean."
Partrick,Carter&WilkinsCo.
Western Electric Co., Hawthorn."

Electro-Mechanical Gongs

Electric Goods Mfg. Co.
Partrick,Carter&WilkinsCo.

Magneto Bells

Electric Goods Mfg. Co.
Kieruliff, B. F., Jr. & Co., "Sterling."
Kellogg Switchboard & Supply Co.
Standard Electric Works, "C. & S."
Western Electric Co.

BOILERS

Moore & Co., Chas. C., "B. & W."
Tracy Engineering Company, "Edge Moor."

BOXES

Wall Boxes

Benjamin Elec. Mfg. Co.
Bossert Electric Construction Co., "Bossert."
Chase Shawmut Co., "Knockout."
Cutter Co., The, "Munit."
General Electric Co.
Paiste, H. T. Co.
Sprague Electric Co., "Universal."
Standard Electrical Works, "M. & M."
Telephone & Elec.Equip.Co.
"Pratt Chuck Co."

BRACKETS

Desk Telephone Brackets

Western Electric Co.

Iron Pole Brackets

Kieruliff, B. F., Jr. & Co., "Cutter."
Pierson, Roeding & Co.
Western Elec. Co., "Fletcher."

BURNERS

Gas Lighting Burners

Electric Goods Mfg. Co., "Advance."
Western Electric Co., "Edwards."

CABLES

Submarine and Lead-Covered

General Electric Co.
Habirshaw Wire Co., "Habirshaw."
Kieruliff, B. F., Jr. & Co., "National."
Okonite Co., "Okonite."
Standard Underground Cable Co.
Simplex Electrical Co., "Simplex."
Western Electric Co., "Hawthorn."

Paper Insulation

Western Electric Co.

Telephone Cable

Kellogg Switchboard and Supply Co.
Western Electric Co.

CARBONS

Arc Light Carbons

Parrott & Co.
Reisinger, Hugo, "Electra," "Nuernberg."

CIRCUIT BREAKERS

American Ever Ready Co.
Cutter Co., The "I-T-E," "Dalite."
Ft. Wayne Electric Works.
General Electric Co.
Kieruliff, Jr. & Co., B. F. "Hartman,"
Western Elec. Co., "I-T-E," "Dalite."
Westghse Elec. & Mfg. Co.

CLAMPS

Ground Clamps.

Bossert Electric Const. Co.
Chase - Shawmut Co., "Shawmut."
Dossert & Co.
General Electric Co.
Paiste Co., H. T. "Perma-Effect."
Thomas & Sons Co., R.

CLEATS.

Fibre Cleats

Blake Signal & Mfg. Co.

Porcelain Cleats

General Electric Co.
Standard Electrical Works, "Standard."
Star Porcelain Co.
Western Elec. Co., "Thomas."

CLUSTERS

Fixture Clusters

Benjamin Electric Mfg. Co. "Anti-Night."
General Electric Co.

COILS

Armature and Field Coils

D. & W. Fuse Co.
General Electric Co.
Western Electric Co., "Deltabeston."
Westghse Elec. & Mfg. Co.

Induction Coils

Electric Goods Mfg. Co.
Kellogg Switchboard and Supply Co.
Partrick,Carter&WilkinsCo.
Western Electric Co.

Spark Coils

Electric Goods Mfg. Co.
Western Electric Co.

COMPOUNDS

Boiler Compounds

Dearborn Drug & Chemical Works
Johns-Manville Co., H. W., "Magic."

CONDUIT

Flexible Conduit

American Circular Loom Co., "Circular Loom."
Sprague Electric Co., "Greenfield."
Telephone & Elec.Equip.Co. "Flexduct."

Rigid Conduit

American Circular Loom Co., "Electroduct."
Kieruliff, B. F., Jr. & Co., "American."
Sprague Electric Co., "Iron Armored."
Telephone & Elec.Equip.Co. "Economy."

Underground Conduit

Johns-Manville Co., H. W., "J-M."
Pierson, Roeding & Co., "Fibre."
Western Electric Co. "Walworth & Neville."

CONNECTORS

Cable Connectors

American Ever Ready Co. "Bulldog."
Dossert & Co.
Kieruliff, B. F., Jr. & Co.,

CORD

Flexible Bell Cord

General Electric Co.
Kieruliff, B. F., Jr. & Co., "National."
Pierson, Roeding & Co., Agents, Elec. Cable Co.
Simplex Elec. Co.
Western Electric Co.

Lamp Cord

General Electric Co.
Okonite Co., The, "Okonite."
Pierson, Roeding & Co., Agents, Elec. Cable Co.
Simplex Elec. Co.
Standard Und. Cable Co.
Western Elec. Co., "Victor."

Telephone Cord.

Kellogg Switchboard and Supply Co.
Kieruliff, B. F., Jr. & Co., "National."
Pierson, Roeding & Co., Agents, Elec. Cable Co.
Simplex Elec. Co.
Western Elec. Co., "Victor."

CROSS ARM BRACES.

Kieruliff, B. F., Jr. & Co.

CUT-OUTS

Arc Cut-Outs

Bryant Electric Co.
Ft. Wayne Elec. Works.
General Electric Co.
Parrott & Co., "Fox."

Incandescent Cut-Outs

Bryant Electric Co.
D. & W. Fuse Co.
General Electric Co.
Paiste Co., H. T., "Shaffer," "K. W.," "P. K.," "Taplets."
Perkins Elec. Swch Mfg Co.
Westghse Elec. & Mfg. Co.

Transformer Cut-Outs

Bryant Electric Co.
D. & W. Fuse Co.
General Electric Co.
Parrott & Co., "Peerless."
Westghse Elec. & Mfg. Co.

DYNAMOS

A. C. Dynamos

Ft. Wayne Elec. Works.
General Electric Co.
Standard Engineering Co.
Western Electric Co.
Westghse Elec. & Mfg. Co.

D. C. Dynamos

Electric Appliance Co., "Colonial."
Ft. Wayne Elec. Works.
General Electric Co.
Parrott & Co., "Diehl."
Standard Engineering Co.
Western Electric Co.
Westghse Elec. & Mfg. Co.

ELECTRIC NOVELTIES

American Ever Ready Co. "Ever Ready."

ENGINES

Gas and Gasoline Engines

Moore & Co., Chas. C.
Henshaw-Bulkley & Co.
Hunt, Mirk & Co., "Westinghouse."
Kieruliff, B. F., Jr. & Co., "American Diesel."
Tracy Engineering Co.
Westinghouse Machine Co.

Marine Engines

Standard Engineering Co., "Engberg."

Steam Engines

Moore & Co., Chas. C.
Hunt, Mirk & Co., "Westinghouse."
Standard Engineering Co.
Tracy Engineering Co., The
Westinghouse Machine Co.

FANS

A. C. Portable Fans

Ft. Wayne Elec. Works.
General Electric Co., "G. E."
Standard Electric Works, "Jandus."
Western Elec. Co., "Victor," "Emerson," "Hawthorn."
Westghse Elec. & Mfg. Co.

D. C. Portable Fans

Ft. Wayne Elec. Works.
General Electric Co., "G. E."
Parrott & Co., "Diehl."
Sprague Electric Co., "Lundell."
Standard Electrical Works, "Jandus."
Western Electric Co., "Hawthorn."
Westghse Elec. & Mfg. Co.

A. C. Ceiling Fans

Standard Elec. Works, "Jandus," "Century."
Western Elec. Co., "Victor," "Emerson."
Westghse Elec. & Mfg. Co.

D. C. Ceiling Fans

General Electric Co.
Parrott & Co., "Diehl."
Sprague Electric Co., "Lundell."
Standard Elec. Works, "Jandus."
Western Electric Co., "Hawthorn."
Westghse Elec. & Mfg. Co.

Exhaust Fans

General Electric Co.
Parrott & Co., "Kimball."
Standard Elec. Wks., "M. A. Co."
Western Elec. Co., "W. E."
Westghse Elec. & Mfg. Co.

FIXTURES

Ceiling, Bracket and Desk Fixtures

Benjamin Elec. Mfg. Co.

Marine Fixtures

Benjamin Elec. Mfg. Co.

Show Case Fixtures

Benjamin Elec. Mfg. Co.
Johns-Manville Co., H. W., "Linolite."

Stage Fixtures

Chase-Shawmut Co., "Shawmut."

FLASHLIGHT (Pocket)

American Ever Ready Co., "Ever Ready."

FUSE MATERIAL

Enclosed Fuses and Fittings

Bryant Electric Co.
Chase-Shawmut Co., "Shawmut."
D. & W. Fuse Co.
General Electric Co.
Johns-Manville Co., H. W., "Noark."
Western Elec. Co., "D. & W."
Westghse Elec. & Mfg. Co.

Fuse Boxes

Including Service Boxes, Subway Boxes and Junction Cut-Outs for use with enclosed fuses.
D. & W. Fuse Co., "D. & W."
Johns-Manville Co., H. W., "Noark."

Fuse Wire and Links.

Chase-Shawmut Co., "Shawmut."
General Electric Co.
Pierson, Roeding & Co., "Aluminum."

Miscellaneous Fuses

Bryant Electric Co.
General Electric Co.
Paiste, H. T. Co., "H. & L."

Telephone Fuses

D. & W. Fuse Co.
Kieruliff, B. F., Jr. & Co., "Sterling."
Standard Elec. Works, "Couch & Seeley."
Western Electric Co.

GOVERNORS.

Water-Wheel Governors

Pierson, Roeding & Co., "Lombard."

GUARDS.

Wire Lamp Guards.

Benjamin Electric Mfg. Co. "Can't Break," "Protectalite."

HANGERS

Cable Hangers

Chase-Shawmut Co., "Boston."
Kieruliff, B. F. Jr. & Co., "National."
Standard Underground Cable Co., "Nordyke Support."

HEATING MATERIAL

Including Cooking Utensils, Soldering Irons, Sad Irons, Etc.
General Electric Co.
Johns-Manville Co., H. W. "Electrotherm."
Simplex Elec. Heating Co. "Simplex."
Vulcan Elec. Heating Co. "Vulcan."
Westghse Elec. & Mfg. Co.

HOODS.

Street Hoods

Ft. Wayne Elec. Works.
General Electric Co.
Kieruliff, B. F., Jr. & Co. "Cutter."
Western Elec. Co., "Fletcher."

INSULATORS

Glass Insulators

Brookfield Glass Company, "Brookfield."
Pierson, Roeding & Co., "Locke Triple Petticoat."
Standard Electrical Works, "Standard."
Western Elec. Co., "Brookfield," "Hemingray."

High-Tension Insulators.

General Electric Co.
Johns-Manville Co., H. W.
Kieruliff, B. F., Jr. & Co. "Ohio Brass."
Pierson, Roeding & Co. "Locke."
Thomas & Sons Co., R.
Western Elec. Co., "Thomas."

Porcelain Insulators

General Electric Co.
Johns-Manville Co., H. W.
Pierson, Roeding & Co. "Locke."
Standard Electrical Works "Standard."
Star Porcelain Co.
Thomas & Sons Co., R.
Western Elec. Co., "Thomas."

Wood Knobs

Blake Signal & Mfg. Co.

INSULATING MATERIAL

Kieruliff, B. F., Jr. & Co. "Di-electric."
Johns-Manville Co., H. W. "Asbestos Wood," "Indurated Fibre," "Vulcabeston," "Monarch," "Phoenix," "Electrobeston."
Standard Underground Cable Co., "Ozite."
Western Electric Co. "Electrose."

LAMPS.

Electric Arc Lamps

Ft. Wayne Electric Works "Wood."
General Electric Co., "G. E."
Parrott & Co., "Radiant Economy."
Standard Electrical Works "Jandus," "Boulevard."
Western Electric Co., "Hawthorne."
Westghse Elec. & Mfg. Co.

Flaming Arc Lamps

General Electric Co., "G. E."
Parrott & Co., "Grant."

PRINT IN BINDING

Western Elec. Co., "Victor."
Westghse Elec. & Mfg. Co.

Incandescent Lamps

California Inc. Lamp Co., "California."
General Elec. Co., "Edison," "Lowatt."
Johns-Manville Co., H. W., "Linolite."
Kieruliff, B. F., Jr. & Co., "Excelsior."
Western Electric Co., "Sunbeam," "Regal."
Westghse Elec. & Mfg. Co. "Westinghouse."

Miniature Lamps.

American Ever Ready Co. "Ever Ready."

Tantalum Lamps

General Elec. Co., "Meridian," "Tantalum."
General Electric Co.
Kieruliff, B. F., Jr. & Co., "Excelsior."
Western Electric Co., "Sunbeam."

Tungsten Lamps

California Inc. Lamp Co., "California."
Johns-Manville Co., H. W.
Kieruliff, B. F., Jr. & Co., "Excelsior."
Parrott & Co., "Kimball."
Western Electric Co., "Sunbeam."
Westghse Elec. & Mfg. Co.

LINE MATERIAL.

Street Ry. Line Material

General Electric Co.
Johns-Manville Co., H. W., "J-M."
Kieruliff, B. F., Jr. & Co., "Lord Electric Co."
Pierson, Roeding & Co., "Ohio Brass Co."
Western Elec. Co., "Electrose."
Westghse Elec. & Mfg. Co.

MACHINES

Refrigerating Machines

Vulcan Iron Works

MINING

Mining Machinery

General Electric Co.
Henshaw, Bulkley & Co.
Moore & Co., Chas. C.
Westghse Elec. & Mfg. Co.
Western Electric Co.

METERS

Ammeters and Voltmeters

American Ever Ready Co. "Every Ready."
Ft. Wayne Elec. Works, "Wood."
General Electric Co.
Johns-Manville Co., H. W., "Victor Combination."
Western Electric Co.
Westghse Elec. & Mfg. Co.
Weston Elec. Instmt. Co.

Gas Meters

Pacific Meter Co.

Wattmeters

Duncan Elec. Mfg. Co., "Duncan," "Monetary."
Ft. Wayne Electric Works.
General Electric Co.
Johns-Manville Co., H. W.
Weston Elec. Instmt. Co.
Westghse Elec. & Mfg. Co.

MOTORS

A. C. Motors

General Electric Co.
Kieruliff, Jr., & Co., B. F., "Ideal."
Parrott & Co., "Kimball."
Standard Electrical Works, "Century."
Telephone & Elec.Equip.Co. "Holtzer-Cabot."
Western Electric Co.
Westghse Elec. & Mfg. Co.

D. C. Motors

Ft. Wayne Electric Works.
General Electric Co.
Parrott & Co., "Diehl."
Standard Electrical Works, "Century."
Telephone & Elec.Equip.Co. "Holtzer-Cabot."
Western Electric Co. "Hawthorn."
Westghse Elec. & Mfg. Co.

MOULDING

American Circular Loom Co., "Lutz."
Johns-Manville Co., H. W., "Electrobestos."

PAINTS.

Insulating Paint

Kieruliff, B. F., Jr. & Co., "Di-electric."
Standard Underground Cable Co., "Ozite."

PINS

Iron Pins

Kieruliff, B. F., Jr. & Co., "Hubbard."
Pierson, Roeding & Co., "Locke."
Thomas & Sons Co., The R., "Lee."
Western Electric Co., "Lee" "Fletcher."

Wood Pins

Kieruliff, B. F., Jr. & Co.
Pierson, Roeding & Co., Eucalyptus and Locust.
Western Electric Co.

PIPE.

Iron and Steel Pipe.

Shaw-Batcher Co., The

Wood Pipe

Portland Wood Pipe Co.

PLUGS.

Attachment Plugs.

Benjamin Elec. Mfg. Co.
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Electric Goods Mfg. Co., "Howes."
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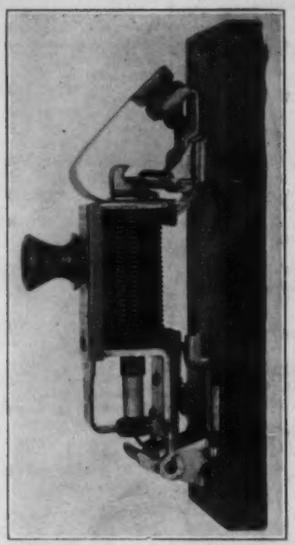

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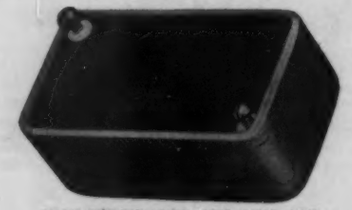

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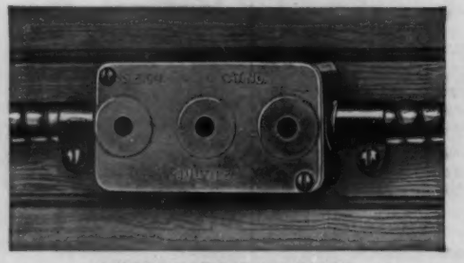

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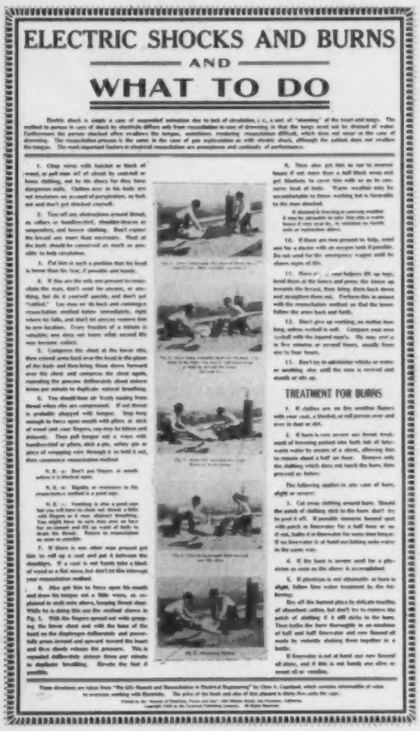

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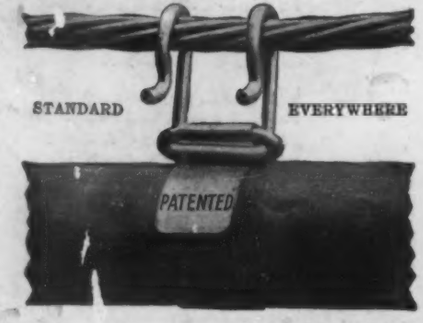

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